UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
1650 Arch Street
Philadelphia, Pennsylvania 19103-2029

September 4, 2013

Mr. Robert A. Mitchell
Corr Mitchell LLC
1035 W Bristol Road
Warminster, Pennsylvania 18974

Re: Freedom of Information Act Request EPA-RE-2013-006021

This letter is in response to your Freedom of Information (FOIA) request dated May 1, 2013, which we received on May 2, 2013, regarding All records related to a petition by the Delaware Riverkeeper Network to investigate potential lead contamination by the Philadelphia Gun Club in the Delaware River.

In accordance with your wishes we are enclosing a Preliminary Assessment Report in connection with the subject matter referenced above. Should you have any questions concerning this matter, please contact Charlene Creamer, Site Assessment Manager, at 215-814-2145.

You may appeal this response to the National Freedom of Information Officer, U.S. EPA, Records, FOIA and Privacy Branch, 1200 Pennsylvania Avenue, NW (2822T), Washington, DC 20460, Fax: (202) 566-2147, E-mail: hq.foia@epa.gov. Only items mailed through the United States Postal Service may be delivered to 1200 Pennsylvania Avenue, NW. If you are submitting your appeal via hand delivery, courier service or overnight delivery, you must address your correspondence to 1301 Constitution Avenue, N.W., Room 6416J, Washington, DC 20004. Your appeal must be made in writing, and it must be submitted no later than 30 calendar days from the date of this letter. The Agency will not consider appeals received after the 30 calendar day limit. The appeal letter should include the RIN listed above. For quickest possible handling, the appeal letter and its envelope should be marked "Freedom of Information Act Appeal."

Sincerely,

Mitch Cron, Acting Chief
Community Involvement and Outreach Branch

Enclosure

Customer Service Hotline: 1-800-438-2474

DELAWARE RIVERKEEPER NETWORK

April 23, 2013

Shawn M. Garvin
Regional Administrator
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103-2029

Re: Preliminary Assessment Request

Dear Mr. Garvin:

Under the authority of CERCLA Section 105(d), as amended, the petitioner, Maya K. van Rossum, as the Delaware Riverkeeper, and on behalf of the Delaware Riverkeeper Network (collectively "DRN"), 925 Canal Street, Suite 3701, Bristol, Pennsylvania 19007, 215-369-1188, hereby requests that Region III of the United States Environmental Protection Agency conduct a preliminary assessment of the release of lead into soil, groundwater, and surface water resulting from decades of lead shot accumulation at the Philadelphia Gun Club (PGC) trap shooting range in Bensalem, Pennsylvania.

As shown on the accompanying map, the PGC trap shooting range is located at 3051 State Road, Bensalem, Pennsylvania, 19020, and is immediately adjacent to the Delaware River. By PGC's own admission, PGC members used lead shot for regular on-site shooting activities from 1880 through at least 1994.[1] The Delaware Riverkeeper, and the members of the DRN, are concerned that residual lead shot accumulated at the ground surface of the shooting range over

[1] PGC claims that the use of lead shot at the shooting range was discontinued in 1994.

DELAWARE RIVERKEEPER NETWORK
925 Canal Street, Suite 3701
Bristol, PA 19007
Office: (215) 369-1188
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drn@delawareriverkeeper.org
www.delawareriverkeeper.org

the course of at least **114 years** of regular shooting activities may at present be releasing lead to near surface soils, groundwater, and surface waters. As discussed in more detail below, a limited soil sampling conducted by DRN near the property line between PGC's site and the Delaware River revealed lead concentrations as high as **1200 mg/kg** in near-surface sediments.

DRN is a non-profit environmental organization that advocates for the protection and restoration of the ecological, recreational, commercial and aesthetic qualities of the Delaware River, its tributaries and habitats. Our service area is the entire Delaware River Watershed. DRN has 10,000 members, including individuals who regularly fish, boat, or otherwise recreate on the Delaware River in the Bensalem area. The Delaware Riverkeeper, a full-time ombudsman who oversees the operations of DRN and works for the protection of the Delaware River and its watershed, also personally recreates in the portion of the river adjacent to PGC's site.
The Delaware Riverkeeper, DRN, and DRN members are concerned about the consequences of lead contamination reaching the river. Because the shooting range site is immediately adjacent to the Delaware River, the Delaware Riverkeeper, DRN, and its members are concerned that lead leaching into the groundwater table, carried over the land surface in stormwater runoff, or otherwise migrating through the environment may be discharging into the Delaware River.

DRN understands that lead shot is approximately 95% lead, which is a hazardous substance due to its toxic effects on humans and wildlife. Based on EPA guidance documents, DRN understands that trap-shooting ranges where lead shot historically has been used for long periods of time may pose a threat to the environment due to the release of lead from accumulated lead shot.[2] DRN does not have any information as to whether PGC has ever undertaken lead

[2] *See* U.S. E.P.A., Region 2, *Best Management Practices for Lead at Outdoor Shooting Ranges*, EPA -902-B-01-001 (June 2005); U.S. E.P.A., Office of Solid Waste and Emergency Response,

testing or lead remediation activities at its Bensalem shooting range. DRN has not contacted any state or local authorities regarding the presence of lead at PGC's site from historical (pre-1994) shooting activities.

On February 25-26, 2013, DRN collected 15 soil samples at the perimeter of the PGC site. As shown on the accompanying map of sample locations, DRN collected these samples along the shoreline, below the low tide line, in order to avoid any possible trespass on PGC property. On the first day of sampling, DRN collected five samples from the top 0-6" of soil using a trowel. On the second day of sampling, DRN collected an additional ten samples from the top 0-12" of soil using a hand auger. Composite soil samples from each location were sent to EMSL Analytical, Inc. in Cinnaminson, New Jersey for analysis for lead by EPA Solid Waste Test Method SW-846 7421.[3] DRN selected EPA Method 7421 in accordance with EPA guidance on soil lead assessment at shooting range sites.[4] Lead concentrations in the five samples collected on February 25, 2013 ranged from 340 mg/kg lead to 700 mg/kg lead. The mean lead concentration for those five samples was 516 mg/kg lead. Lead concentrations in the ten samples collected on February 26th, 2013 ranged from 150 mg/kg to 1200 mg/kg. The mean lead concentration for those ten samples was 505 mg/kg lead. The samples consisted of sandy and gravelly silts. The samples were not sieved prior to testing. Consequently, the lead concentrations here are for the total sample, including the sandy and gravelly fraction, and therefore likely <u>under</u>-represent the amount of lead present in the finer fractions of the sediment.

TRW Recommendations for Performing Human Health Risk Analysis on Small Arms Shooting Ranges, OSWER #9285.7-37 (March 2003).

[3] According to EPA's January 2013 National Lead Laboratory Accreditation Program List, EMSL Analytical is accredited to perform lead testing by both the American Association for Laboratory Accreditation and the American Industrial Hygiene Association.

[4] U.S. E.P.A., Office of Solid Waste and Emergency Response, *TRW Recommendations for Performing Human Health Risk Analysis on Small Arms Shooting Ranges*, OSWER #9285.7-37 (March 2003).

Furthermore, samples were collected from five to ten feet riverward of the low tide line, along a sloping shoreline, which may also skew the concentrations downward relative to on-site concentrations.

SAMPLE ID	COLLECTION DEPTH	LEAD (MG/KG)
A	0-6"	340
B	0-6"	560
C	0-6"	370
D	0-6"	700
E	0-6"	610
A2	0-6"	270
B2	0-6"	280
C2	0-6"	250
D2	0-6"	340
E2	0-4"	150
F2	0-5"	650
G2	0-8"	**1200**
H2	0-6"	540
I2	0-12"	**1100**
J2	0-12"	270

Based on the fact that this very limited random sampling conducted adjacent to the PGC site revealed lead concentrations in two samples exceeding the non-residential lead screening level of 800 mg/kg recommended by EPA[5], and mean lead concentrations exceeding the residential lead screening level of 400 mg/kg[6], DRN is concerned that on-site lead concentrations in surface soils at the PGC shooting range may be far higher, and that the PGC site may be actively releasing high levels of lead into ground and surface waters reaching the Delaware River.

[5] *See* U.S. E.P.A., *Addressing Lead at Superfund Sites, Frequent Questions from Risk Assessors on the Adult Lead Methodology*, http://www.epa.gov/superfund/lead/almfaq.htm (last accessed Mar. 12, 2013).
[6] *See* U.S. E.P.A., *Office of Solid Waste and Emergency Response, Memorandum: OSWER Directive: Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*, OSWER # 9355.4-12 (Aug. 1994).

DRN believes that testing of on-site soils at PGC's shooting range to evaluate soil lead concentrations is warranted by the historical use of lead shot at the site for at least 114 years and the results of DRN's soil testing outside, but directly adjacent to, the boundaries of the PGC site.

Sincerely,

Maya K. van Rossum, the Delaware Riverkeeper

Delaware Riverkeeper Network
925 Canal Street
Suite 3701
Bristol, PA 19007
tel. 215-369-1188 ext. 102
fax 215-369-1181
keepermaya@delawareriverkeeper.org

encl

cc: Ronald Borsellino, Director
Hazardous Site Cleanup Division
U.S. Environmental Protection Agency
Mailcode: 3HS00
1650 Arch Street
Philadelphia, PA 19103-2029

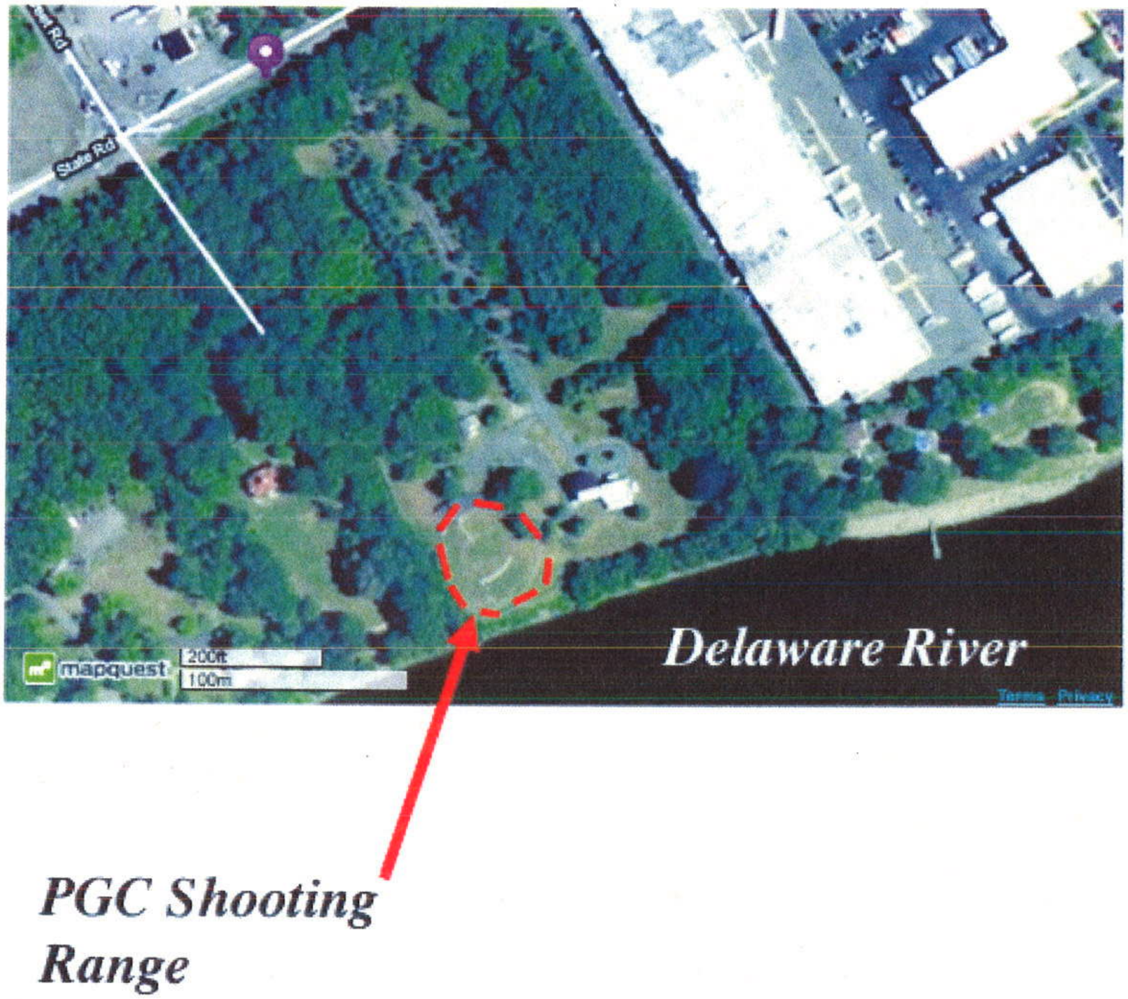
RECEIVED

APR 2 [illegible] 2013

EPA, REGION III
OFFICE OF REGIONAL ADMINISTRATOR

ATTACHMENTS

Map of PGC Shooting Range Located at 3051 State Road, Bensalem, PA 19020



SOIL SAMPLING METHODOLOGY

On February 25th, 2013, samples A through E were collected using an aluminum hand trowel. Sampling locations were located approximately five to seven feet riverward of the low tide line. The trowel was sprayed with distilled water prior to the collection of each sample to avoid cross-contamination. At each of the five sampling locations, the trowel was used to collect a bulk sample from the top 0 to 6" inches of sediment. Each bulk sample was placed in a clean glass jar[7] and mixed thoroughly using a clean stainless steel spoon to composite the sample. Approximately 100 grams of the composite material was then spooned into glassware provided by EMSL Analytical. The stainless steel spoon was sprayed with distilled water between samples to avoid cross-contamination. Samples were placed in a cooler provided by EMSL Analytical and transported to EMSL. EMSL provided the analytical results to DRN on March 11, 2013.

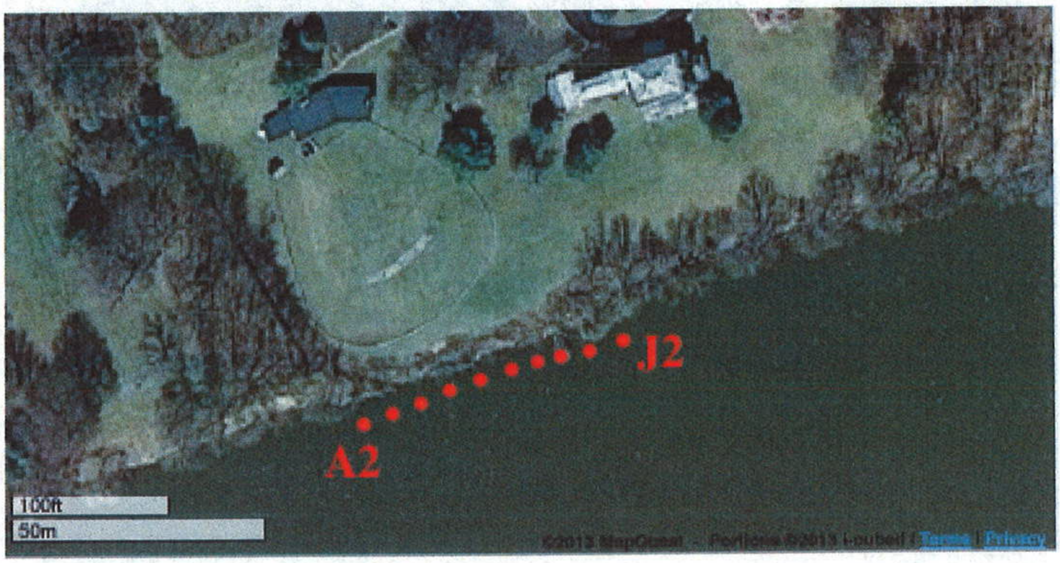
On February 26th, 2013, samples A2 through I2 were collected using a stainless steel hand auger. Sampling locations were located seven to ten feet riverward of the low tide line. The auger was sprayed with distilled water prior to the collection of each sample to avoid cross-contamination. At each of the five sampling locations, the auger was used to collect a bulk sample from the top 0 to 12" inches of sediment. The sampling depth varied from location to location based on the ability of the sampler to push the hand auger through gravelly layers of sediment. Each bulk sample was placed in a clean glass jar[8] and mixed thoroughly using a clean

[7] To verify that glassware was uncontaminated, random samples of the glassware from the same case as those used for compositing bulk samples were wipe-tested for lead by Method SW-846-7000B. Samples were analyzed by EMSL Analytical. No lead was detected. (Non-detect threshold of 10 ug/wipe.)

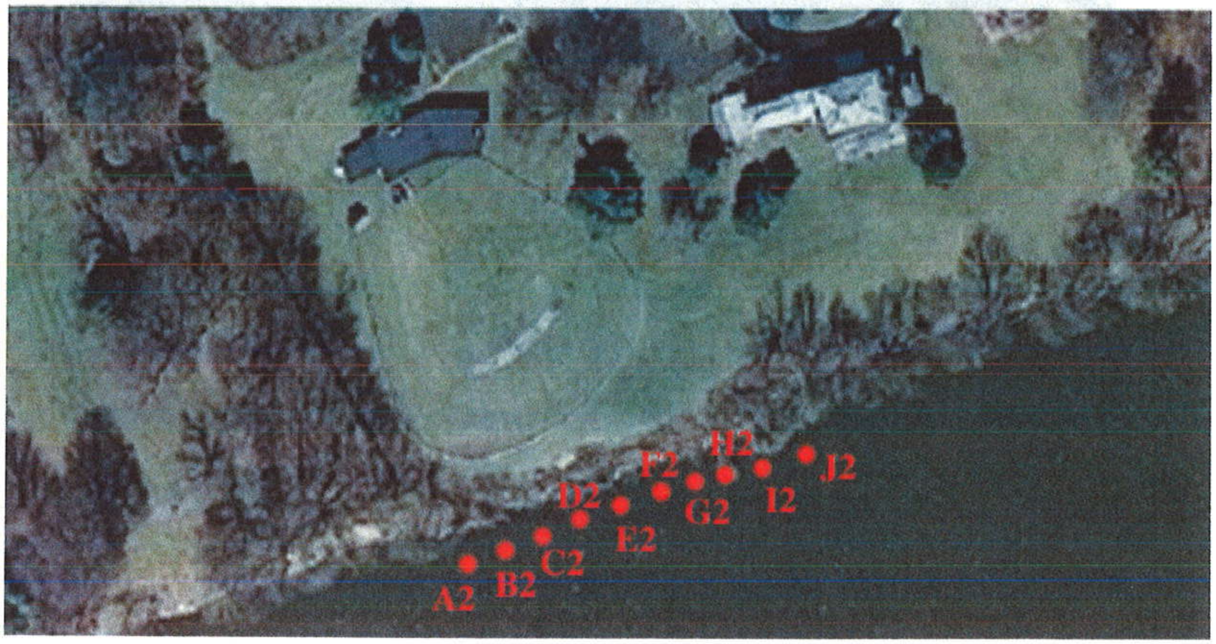
[8] To verify that glassware was uncontaminated, random samples of the glassware from the same case as those used for compositing bulk samples were wipe-tested for lead by Method SW-846-7000B. No lead was detected. Samples were analyzed by EMSL Analytical. (Non-detect threshold of 10 ug/wipe.)

stainless steel spoon to composite the sample. Approximately 100 grams of the composite material was then spooned into glassware provided by EMSL Analytical. The stainless steel spoon was sprayed with distilled water between samples to avoid cross-contamination. Samples were placed in a cooler provided by EMSL Analytical and transported to EMSL. EMSL provided the analytical results to DRN on March 11, 2013.

APPROXIMATE SAMPLING LOCATIONS



APPROXIMATE SAMPLING LOCATIONS [ALTERNATIVE VIEWS]



ANALYTICAL RESULTS

EMSL Analytical, Inc.

200 Route 130 North, Cinnaminson, NJ 08077
Phone/Fax: (856) 303-2500 / (856) 786-5974
http://www.emsl.com cinnaminsonleadlab@emsl.com

EMSL Order:	201301773
CustomerID:	DRKN34
CustomerPO:	CC 02484C
ProjectID:	

Attn: **Nicholas Patton**
Delaware Riverkeeper Network
925 Canal Street
Suite 3701
Bristol, PA 19007

Phone: (215) 369-1188
Fax:
Received: 02/25/13 7:04 PM
Collected:

Project: **PGC**

Test Report: Pb by Graphite Furnace Atomic Absorption

Client Sample Description	*Lab ID*	*Collected*	*Analyzed*	*Lead Concentration*
A	0001		3/5/2013	340 mg/Kg
Site: Adjacent to PGC Property Location A				
B	0002		3/5/2013	560 mg/Kg
Site: Adjacent to PGC Property Location B				
C	0003		3/5/2013	370 mg/Kg
Site: Adjacent to PGC Property Location C				
D	0004		3/5/2013	700 mg/Kg
Site: Adjacent to PGC Property Location D				
E	0005		3/5/2013	610 mg/Kg
Site: Adjacent to PGC Property Location E				

Julie Smith

Julie Smith - Laboratory Director
NJ-NELAP Accredited:03036
or other approved signatory

Reporting limit is 40 mg/kg based on a 0.5 gram sample weight. The QC data associated with these sample results included in this report meet the method quality control requirements, unless specifically indicated otherwise. Unless noted, results in this report are not blank corrected . This report relates only to the samples reported above and may not be reproduced, except in full, without written approval by EMSL. EMSL bears no responsibility for sample collection activities. "<" (less than) result signifies that the analyte was not detected or at about the reporting limit.

* slight modifications to methods applied Samples received in good condition unless otherwise noted. Quality Control Data associated with this sample set is within acceptable limits, unless otherwise noted
Samples analyzed by EMSL Analytical, Inc. Cinnaminson, NJ

Initial report from 03/11/2013 14:30:30

EMSL Analytical, Inc.

200 Route 130 North, Cinnaminson, NJ 08077
Phone/Fax: (856) 303-2500 / (856) 786-5974
http://www.emsl.com cinnaminsonleadlab@emsl.com

EMSL Order: 201301776
CustomerID: DRKN34
CustomerPO: CC 02484C
ProjectID:

Attn: **Nicholas Patton**
Delaware Riverkeeper Network
925 Canal Street
Suite 3701
Bristol, PA 19007

Phone: (215) 369-1188
Fax:
Received: 02/26/13 11:36 AM
Collected: 2/26/2013

Project: **PGC Sampling 2**

Test Report: Pb by Graphite Furnace Atomic Absorption

Client Sample Description	*Lab ID*	*Collected*	*Analyzed*	*Lead Concentration*
A2	*0001*	2/26/2013	3/5/2013	270 mg/Kg
Site: Adjacent PGC Property				
B2	*0002*	2/26/2013	3/5/2013	280 mg/Kg
Site: Adjacent PGC Property				
C2	*0003*	2/26/2013	3/5/2013	250 mg/Kg
Site: Adjacent PGC Property				
D2	*0004*	2/26/2013	3/5/2013	340 mg/Kg
Site: Adjacent PGC Property				
E2	*0005*	2/26/2013	3/5/2013	150 mg/Kg
Site: Adjacent PGC Property				
F2	*0006*	2/26/2013	3/5/2013	650 mg/Kg
Site: Adjacent PGC Property				
G2	*0007*	2/26/2013	3/5/2013	1200 mg/Kg
Site: Adjacent PGC Property				
H2	*0008*	2/26/2013	3/5/2013	540 mg/Kg
Site: Adjacent PGC Property				
I2	*0009*	2/26/2013	3/5/2013	1100 mg/Kg
Site: Adjacent PGC Property				
J2	*0010*	2/26/2013	3/5/2013	270 mg/Kg
Site: Adjacent PGC Property				

Julie Smith

Julie Smith - Laboratory Director
NJ-NELAP Accredited:03036
or other approved signatory

Reporting limit is 40 mg/kg based on a 0.5 gram sample weight. The QC data associated with these sample results included in this report meet the method quality control requirements, unless specifically indicated otherwise. Unless noted, results in this report are not blank corrected . This report relates only to the samples reported above and may not be reproduced, except in full, without written approval by EMSL. EMSL bears no responsibility for sample collection activities. "<" (less than) result signifies that the analyte was not detected or at about the reporting limit.

* slight modifications to methods applied Samples received in good condition unless otherwise noted. Quality Control Data associated with this sample set is within acceptable limits, unless otherwise noted
Samples analyzed by EMSL Analytical, Inc. Cinnaminson, NJ

Initial report from 03/11/2013 14:30:54

EMSL Analytical, Inc.
200 Route 130 North, Cinnaminson, NJ 08077
Phone/Fax: (856) 303-2500 / (856) 786-5974
http://www.emsl.com cinnaminsonleadlab@emsl.com

EMSL Order:	201302334
CustomerID:	DRKN34
CustomerPO:	
ProjectID:	

Attn: **Nicholas Patton**
Delaware Riverkeeper Network
925 Canal Street
Suite 3701
Bristol, PA 19007

Phone: (215) 369-1188
Fax:
Received: 03/14/13 6:23 PM
Collected: 3/14/2013

Project: **PGC Jar Sampling**

Test Report: Lead in Dust by Flame AAS (SW 846 3050B*/7000B)

Client Sample Description	*Lab ID*	*Collected*	***Analyzed***	*Area Sampled*	***Lead Concentration***
A	*0001*	3/14/2013	3/18/2013	n/a	<10 µg/wipe
Site: Quart Sized Jar					
B	*0002*	3/14/2013	3/18/2013	n/a	<10 µg/wipe
Site: Pint Sized Jar					

Julie Smith

Julie Smith - Laboratory Director
NJ-NELAP Accredited:03036
or other approved signatory

Reporting limit is 10 ug/wipe. ug/wipe = ug/ft2 x area sampled in ft2. Unless noted, results in this report are not blank corrected. This report relates only to the samples reported above and may not be reproduced, except in full, without written approval by EMSL. EMSL bears no responsibility for sample collection activities (such as volume sampled) or analytical method limitations. Samples received in good condition unless otherwise noted. QC data associated with this sample set is within acceptable limits, unless otherwise noted. The lab is not responsible for data reported in µg/ft² which is dependant on the area provided by non-lab personnel. The test results contained within this report meet the requirements of NELAC unless otherwise noted. * slight modifications to methods applied. "<" (less than) results signifies that the analyte was not detected at or above the reporting limit. Measurement of uncertainty is available upon request.

Samples analyzed by EMSL Analytical, Inc. Cinnaminson, NJ NELAP Certifications: NJ 03036, NY 10872, PA 68-00367, AIHA-LAP, LLC ELLAP 100194, A2LA 2845.01

Initial report from 03/19/2013 12:20:40

EPA GUIDANCE DOCUMENTS ON LEAD AT SHOOTING RANGES

U.S. EPA
OSWER #9285.7-37
March 2003

TRW RECOMMENDATIONS FOR PERFORMING HUMAN HEALTH RISK ANALYSIS ON SMALL ARMS SHOOTING RANGES

Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

NOTICE

This document provides guidance to EPA staff. It also provides guidance to the public and to the regulated community on how EPA intends to exercise its discretion in implementing the National Contingency Plan. The guidance is designed to implement national policy on these issues. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus, it cannot impose legally-binding requirements on EPA, States, or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA may change this guidance in the future, as appropriate.

U.S. Environmental Protection Agency
Technical Review Workgroup for Lead

The Technical Review Workgroup for Lead (TRW) is an interoffice workgroup convened by the U.S. EPA Office of Solid Waste and Emergency Response/Office of Emergency and Remedial Response (OSWER/OERR).

Co-Chairpersons

Region 8
Jim Luey
Denver, CO

NCEA/Washington
Paul White

Members

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Mary Ballew
Boston, MA

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Mark Maddaloni
New York, NY

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Atlanta, GA

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Dallas, TX

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Michael Beringer
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Harlal Choudhury

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Robert Elias

OERR Mentor
Larry Zaragoza
Office of Emergency and Remedial Response
Washington, DC

Executive Secretary
Richard Troast
Office of Emergency and Remedial Response
Washington, DC

Associate
Scott Everett
Department of Environmental Quality
Salt Lake City, UT

Executive Summary

Past management practices at small arms outdoor shooting ranges (subsequently referred to as 'ranges') allowed the spent ammunition to accumulate on site. Many range operators now recognize the risk posed to humans and the environment by spent lead ammunition and have implemented programs to manage and recycle lead shot and bullets. In accordance with its mission to provide scientifically sound and consistent guidance on lead risk assessment, the TRW has prepared this document to provide guidance and recommendations for performing risk assessment on land currently or formerly used as ranges. This document supplements Region 2's Best Management Practices for Lead at Outdoor Shooting Ranges (U.S. EPA, 2001a), which serves as national guidance on the management of lead at ranges to minimize the environmental impact of spent lead ammunition (U.S. EPA, 2001b).

As used in this document, the term 'small arms' includes rifles, handguns (pistols), shotguns, submachine guns, and machine guns (NRA, 1999, p. I-8). Ranges can be divided into high velocity shooting ranges, where target shooting with pistols and rifles occurs, and low velocity shooting ranges where shotguns are used (i.e., skeet, trap, and sporting clay ranges). Lead bullets and fragments at pistol and rifle ranges are typically contained in a relatively small, well-defined area, or volume, of sand and/or soil. The shotfall zones at skeet and trap ranges may cover 10–50 acres or more, depending upon the layout of the range.

This document contains brief discussions of the regulatory background for outdoor shooting ranges and the toxicology of lead on humans, an operational and physical description of the different types of outdoor shooting ranges, and the fate of spent lead ammunition in the environment and its bioavailability. This document provides recommendations on how the Integrated Exposure Uptake Biokinetic model and the Adult Lead model can be used to predict the risk to human health from spent lead ammunition on small arms shooting ranges.

BACKGROUND AND PURPOSE

There are approximately 9,000 outdoor small arms shooting ranges (subsequently referred to as 'ranges') in the United States, excluding those located on military sites (U.S. EPA, 2001a).Millions of pounds of lead are discharged annually at these ranges (U.S. EPA, 2001a). In the past, the common practice at ranges was to allow the spent ammunition to accumulate on site. Many range operators now recognize the risk posed to humans and the environment by the lead in spent ammunition and have implemented programs to manage and recycle lead shot and bullets.

Given the large number of ranges in the United States and their potential risk to humans, the Technical Review Workgroup for Lead (TRW) has prepared this document to assist Regional and State risk assessors and project managers in performing risk assessments at range sites. The proper management of lead at shooting ranges is addressed in an EPA Region 2 document entitled 'Best Management Practices for Lead at Outdoor Shooting Ranges' (U.S. EPA, 2001a). This white paper contains the TRW's recommendations on how to collect data that will be used to provide site specific information when using the Integrated Exposure Uptake Biokinetic (IEUBK) Model and the Adult Lead Model (ALM) (U.S. EPA, 2002c). The focus of this document is on formerly used ranges, although exposure to active ranges may occur and is also discussed.

INTRODUCTION

As used in this document, the term 'small arms' includes rifles, handguns (pistols), shotguns, submachine guns, and machine guns (NRA, 1999, p. I-8). Spent ammunition on ranges is not regulated as solid/hazardous waste unless it is discarded (abandoned) and left to accumulate for a long period of time (U.S. EPA, 2001a). Furthermore, it is not regulated if the spent ammunition is recovered or reclaimed on a regular basis (U.S. EPA, 2001a). However, if the range poses an imminent or substantial danger to health or the environment it can be addressed through Resource Conservation and Recovery Act (RCRA) (U.S. EPA, 2001a).

The intake of lead has a wide variety of effects on humans. Adults and children exposed to lead are susceptible to neurotoxic effects (ATSDR, 1999). Lead may also increase blood pressure and cause anemia; high levels of exposure to lead may damage the brain and kidneys and even cause death (ATSDR, 1999; U.S. EPA, 2002b). High levels of exposure may cause miscarriages, retard fetal development, and damage the organs responsible for sperm production (ATSDR, 1999; U.S. EPA, 2002b). Other effects of lead exposure include irritability, poor muscle coordination, muscle and joint pain, memory and concentration problems, digestive problems, and hearing and vision impairment (U.S. EPA, 2001a, 2002b). In children, lead exposure can cause behavioral and learning problems, hearing problems, impairment of vision and motor skills, hyperactivity, and developmental delays (ATSDR, 1999; U.S. EPA, 2001a, 2002b). Blood lead concentrations of 10µg/dL or less have been associated with adverse health effects in children (U.S. EPA, 1986a; CDC, 1991). It is EPA policy to limit exposure to lead such that the probability of a typical (or hypothetical) child, or group of similarly exposed children, having or exceeding the 10µg/dL blood lead concentration is less than 5% (U.S. EPA, 1994a).

Other chemicals of potential concern at shooting ranges include arsenic and antimony (components of ammunition), nickel (coating on some lead shot), copper, zinc, strontium, and magnesium (present in tracer munitions that are used in machine guns), and polycyclic aromatic hydrocarbons (present in petroleum 'pitch' found in clay targets used at skeet and trap ranges and in 'wadding' from shotgun shells) (Jorgensen and Willems, 1987; EEA, 1992; EA, 1995; Peddicord and LaKind, 2000).Lead shot contains primarily lead (97%), antimony (2%), arsenic (0.5%), and sometimes nickel (0.5%) (Jorgensen and Willems, 1987; Lin et al., 1995). The crust material surrounding lead shot contains between 0.5 and 2.0% antimony, 0.15% nickel, and trace amounts of arsenic (Jorgensen and Willems, 1987). Lead bullets are composed of 90–99% lead, 1–10.5% antimony, and 0.1% copper (EA, 1996). Baer et al. (1995) determined that clay targets ('pigeons') contain approximately 2/3 dolomitic sandstone and 1/3 pitch; painted targets also contain approximately 1% fluorescent paint.

Due to a ban on the use of lead shot for waterfowl hunting and in waterfowl production areas by the U.S. Fish and Wildlife Service (U.S. FWS, 1999, 2001), other less toxic materials have been introduced, such as bismuth, steel, tungsten/iron, and tungsten polymers (a list is provided in EPA, 2001a, Appendix B). However, due to the higher cost of shot that is manufactured with the less toxic material, lead shot continues to be the most commonly used material on skeet and trap shooting ranges (U.S. EPA, 2001b).

Types of Shooting Ranges

Ranges can be divided into high velocity shooting ranges, where target shooting with pistols and rifles occurs, and low velocity shooting ranges where shotguns are used (i.e., skeet, trap, and sporting clay ranges). Appendix A contains a list of on-line sources of additional information for small arms outdoor shooting ranges.

High Velocity (Pistol and Rifle) Shooting Ranges

High velocity ranges consist of a firing line, targets, backstop (to contain bullets and fragments), side berms (to contain ricochets), and ground and overhead baffles (to contain 'short' and 'long' shots, respectively) (Vargas, 1996). Not all ranges, particularly older ranges, will include all these components. Typical lengths for ranges vary between 25 yards and 200 meters (642 yards) (Vargas, 1996); widths depend on the number of firing stations.

The backstop is required to contain the bullets and bullet fragments. Backstops traditionally consist of earthen berms, typically between 15 and 25 feet high. More recently, earthen berms have been replaced with sand traps, steel traps, and rubber traps (U.S. EPA, 2001a). Other innovations have been developed for backstops, such as Shock Absorbing Concrete (SACON) that has been used on some Department of Defense (DOD) ranges since the 1980s (U.S. EPA, 2001a). The purpose of the newer types of backstops/bullet containment devices is to facilitate the collection of bullets and bullet fragments, which substantially reduces the amount of contaminated media generated by the range.

Low Velocity (Shotgun) Shooting Ranges

Shotguns are used to shoot clay targets ('pigeons' or 'birds') on skeet, trap, and sporting clay ranges. In many cases, skeet and trap shooting takes place in one range. A typical trap range consists of five-shooting positions and one structure, the 'traphouse', from which the targets are thrown by a machine called a 'trap'. The angle at which the targets are thrown varies within an arc of 45 degrees (in a horizontal plane). The shooting positions are located 16 yards from the traphouse (Capital Trap Club, 2001a). At skeet ranges, targets are released from two structures, the 'high house' and the 'low house.' There are eight-shooting positions arranged along an arc between the two houses. At the top of the arc, the shooter is approximately 30 yards from the line that connects the two houses (Capital Trap Club, 2001b). The actual layout of skeet and trap ranges varies widely between sites (e.g., EA, 1995; E&E, 1997; Murray et al., 1997).

The size and shape of the shotfall zone is a function of the layout of the site, and ranges from rectangular for sites with multiple ranges located next to each other (e.g., E&E, 1997), to semi-circular for sites with one range (e.g., EA, 1995). The outfall zone from trap shooting will tend to be less than for skeet shooting due to the angle at which shooting occurs. In skeet shooting, the targets are thrown overhead and the shooting angle is approximately 45 degrees from the horizontal. Targets are released much closer to the ground in trap shooting; the shooting angle is approximately horizontal. Another factor that affects the distance the shot will travel is the size of the shot used. When the shooting angle is approximately horizontal, the maximum distance shot will travel varies from 198 yards for No. 8 shot to 330 yards for No. 2 shot (Baldwin, 1994). Number 6 shot will cover an area between 300 and 700 feet from the shooting position when the shooting angle is level; if released from an angle of 40 degrees from the horizontal, the shot will drop between 400 and 900 feet from the shooting position (Baldwin, 1994).

Fate of Lead Ammunition in the Environment and Bioavailability

Lead ammunition oxidizes in the environment, forming a crust around the shot; this crust contains lead carbonates and sulfates (Jorgensen and Willems, 1987; Manninen and Tanskanen, 1993; Lin et al., 1995; EA, 1996; Murray et al., 1997). The predominate lead carbonates that have been found in the crust material include hydrocerussite ($Pb_3(CO_3)_2(OH)_2$) and cerussite ($PbCO_3$); the predominate lead sulfate compound is anglesite ($PbSO_4$). The rate of oxidation depends upon several environmental factors including: oxidation/reduction potential, ionic strength, pH, oxygen content of the soil and the presence of compounds (e.g., phosphate) that may inhibit oxidation (Jorgensen and Willems, 1987; EA, 1996). At some point, the presence of the crust material appears to inhibit the further weathering of the ammunition (Jorgensen and Willems, 1987). While metallic lead is insoluble under typical environmental conditions, lead is released to the environment through the dissolution of the lead compounds found in the crust material (Jorgensen and Willems, 1987; Manninen and Tanskanen, 1993; Lin et al., 1995; EA, 1996; Murray et al., 1997). The solubility of the lead compounds is affected by pH, eH, the presence of carbonate, sulfate, sulfide, phosphate and chloride, and the organic matter content of the soil (Jorgensen and Willems, 1987; Manninen and Tanskanen, 1993; Lin et al., 1995; EA, 1996; Murray, 1997).

Site-specific environmental factors that affect weathering rates of lead on shooting ranges include the amount of precipitation, pH of rain water, slope of the ground surface, amount of organic material present on the ground surface (e.g., leaves, peat) and soil type (U.S. EPA, 2001a). In general, weathering of lead ammunition will increase with increasing precipitation amounts, increase with decreasing pH, increase with increasing chloride concentration, decrease with increasing ground slope (due to decrease in contact time between precipitation and ammunition) and increase with increasing organic matter cover (U.S. EPA, 2001a). Disturbance of the soil (e.g., soil cultivation of agricultural fields) may increase the decomposition of lead ammunition (Jorgensen and Willems, 1987).Bundy et al. (1996) found high corrosion rates were negatively correlated with corrosion potential and soil resistance, two characteristics of the soil environment that can be measured in the field.

The weathering rate of small arms ammunition may be affected by the presence of a copper 'jacket' or metal casing that surrounds the lead core of some ammunition (Major, 2003).The contact between the different types of metals may create a galvanic couple that increases the rate of corrosion of the ammunition if the moisture content of the surrounding soil is sufficiently high.However, on some sites, jacketed bullets do not appear to corrode at a faster rate than unjacketed bullets (Hall, 2002). Jacketed bullets are common on small arms ranges that are located on DOD sites because the military is required to use jacketed bullets; jacketed bullets are much less common on non-military ranges (Hall, 2002). Bullet jackets typically contain (by weight) 89–95% copper, 0.03–0.05 % lead, 0.05% iron, and 5–10 % zinc (Battelle, 1997).

The bioavailability of lead compounds varies greatly from lead sulfates, which have relatively low bioavailability (<25% bioavailable), to lead carbonates (>75% bioavailable) (Henningsen et al., 1998). The overall bioavailability of lead at shooting ranges depends upon the relative amounts of lead carbonates and lead sulfates that are present in the soil. Equilibrium diagrams (i.e., eH-pH diagrams) predict lead sulfates to be the dominant form of lead at pHs <5.3, carbonates to be the dominant form at pHs between 5.3 and 8.5, and lead hydroxides to dominate at pHs >8.5 (EA, 1996).The speciation found at a particular site will also vary depending upon the amount of carbonate and sulfate present in the soil (EA, 1996).

SITE CHARACTERIZATION AND RISK ASSESSMENT

An important difference between high velocity ranges and low velocity ranges, with respect to risk assessment, is the size of the areas impacted by each type of range. Lead bullets and fragments at pistol and rifle ranges are typically contained in a relatively small, well-defined area, or volume, of sand and/or soil. Very little contamination may be found at a well-designed range equipped with bullet traps, although some traps and targets (e.g., steel targets) may generate lead dust and particulates that can be transported by air and water and contaminate the surrounding area.

Due to the relatively small size of typical pistol and rifle ranges, the risks posed to human and ecological receptors are typically low. Exceptions to this would include former ranges that are planned for development, or are currently used for activities that could result in exposure to human and ecological receptors. Risks to human and ecological receptors from exposure to lead and other contaminants at skeet and trap ranges may be moderate to severe, due to the size of the shot outfall area.In some cases, the outfall areas are located within or near wetlands and surface water, which tends to increase the risks to ecological receptors, particularly waterfowl (EA, 1995; E&E, 1997; U.S. EPA, 2001a).

The difference between the types of exposures at high velocity and low velocity ranges also warrant consideration in the exposure assessment. These differences are due to the nature of the lead contamination in soil. At high velocity ranges, in addition to whole bullets and fragments, small particles of lead will be present due to the partial disintegration of the bullets upon impact with the targets and soil and rock particles in the berms (EA, 1996). Less disintegration of the bullets can be expected where fully jacketed and partially jacketed bullets are used (e.g., military ranges).At low velocity ranges, the lead shot will tend to be less fragmented due to the lower velocities.Although lead shot does break down in the environment, complete decomposition of the lead is a slow process that may take 30–300 years, depending upon site conditions (Jorgensen and Willems, 1987; EA, 1996).

Exposure Scenarios and Pathways

Land use adjacent to and near shooting ranges should be considered when developing current and future exposure scenarios for a site. Under the current land use scenario, the potentially exposed human populations of particular concern at an operating range are residents of adjacent residential properties, residents and farm workers on adjacent agricultural properties, and workers who are employed on adjacent commercial properties. Other receptors include trespassers who use the site for recreational purposes such as fishing, hunting, and hiking (Peddicord and LaKind, 2000; U.S. EPA, 2001a), as well as other recreational users when the range is located on or within an area that is used for recreational activities other than target shooting (e.g., multi-use parks).Under future land use scenarios, the potentially exposed population depends upon the intended or actual land use, which may include residential, agricultural, commercial, or industrial uses.

The potentially exposed populations under both future and current land use scenarios that should be considered are:

- Residential land use:
  - children under the age of 7 years old
  - adults
- Agricultural land use (farm family or subsistence farm family):
  - children under the age of 7 years old
  - adults
  - farm workers
- Commercial and industrial land use:
  - adults
  - trespassers
  - maintenance staff/construction workers who may be exposed during invasive work (e.g., excavating trenches to install/repair utilities)

The main pathway for human exposure to lead at shooting ranges is through incidental ingestion of contaminated soil (Peddicord and LaKind, 2000; U.S. EPA, 2001a).The ingestion of site-raised meat (beef, pork, chicken) and fruits and vegetables contaminated with lead dust may also pose a risk for local residents and especially for local farm families; these pathways must be evaluated in the latter scenario. Grazing farm animals may ingest and bioaccumulate large quantities of lead [Braun et al.,1997]. In addition, the inhalation of dust/soil particles may be a potential pathway depending upon site conditions, particularly during activities that involve the excavation of soil (e.g., during maintenance and construction work), or during agricultural activities (e.g., tilling, planting, and plowing) that may release clouds of dust. Hunters (and poachers) may be exposed via consumption of lead-contaminated wildlife (EA, 1995; E&E, 1997; Peddicord and LaKind, 2000; U.S. EPA, 2001a).Children who exhibit pica behavior may be at risk from exposure to formerly used shooting range sites; however, the pica child will not be considered in this document. In most cases, the primary receptor of concern will be children and farmers who are potentially exposed to formerly used ranges and adjacent contaminated areas. (The subsistence farm family ingestion rate of relevant meat or site-raised crops is assumed to comprise a large part of the diet; data is currently available in the Exposure Factors Handbook to evaluate this scenario and the EPA Default Exposure Factors Workgroup is developing default values as well.)

Ecological receptors of concern at shooting ranges include invertebrates, fish, mammals and birds, particularly waterfowl. Pathways include the incidental ingestion of soil, intentional ingestion of lead fragments as grit, and the ingestion of contaminated food items. Risk assessments at shooting ranges have predicted unacceptable levels of risk from lead for raptors, and small (e.g., mice) and large (e.g., fox and deer) terrestrial mammals (EA, 1995; Peddicord and LaKind, 2000). The highest risks from lead have been predicted for small mammals and birds that ingest lead shot incidentally while feeding, or intentionally as grit (EA, 1995; Peddicord and LaKind, 2000). The predicted adverse effects of lead on small mammals and birds, are supported by the literature, which has shown mortality may result from the ingestion of one lead pellet (e.g., Ma, 1989; Roscoe et al., 1989; Hoffman et al., 2000; Vyas et al., 2000). Additional information is available from the EPAECOTOX database (U.S. EPA, 2002a). Consultation with an ecotoxicologist is recommended when planning an ecological risk assessment.

Soil Sampling Strategies and Recommendations

This section is divided into three subsections: 1) General Sampling Strategy, 2) Sample Collection at High Velocity Ranges, and 3) Sample Collection at Low Velocity Ranges.The overall sampling strategy and soil recommendations that are common to both types of ranges are discussed in the General Sampling Strategy subsection. Recommendations that are specific to the two types of ranges are provided in the second and third subsections.

General Sampling Strategy. Sampling may be required to support several different management strategies at a shooting range. The initial visual inspection of the site and a review of operating records may indicate that sufficient spent ammunition exists, making removal and recycling cost effective. For small ranges, particularly pistol and rifle ranges, it may be cost effective to remove or remediate contaminated material rather than conduct a risk assessment.In this case, an initial sampling maybe conducted to determine the amount and type of sampling data required to characterize the material for treatment or disposal, followed by a screening to ensure the remaining soil does not pose a potential risk. Even when recycling will not be a primary management strategy for the site, it is recommended to reclaim spent ammunition from the range prior to collection of data to support a risk assessment in order to avoid duplication of effort. The risk assessment may be conducted to determine the potential for imminent risk, evaluate the risk posed by residual levels of lead in soil, or to develop further management strategies. A first step in the risk assessment is to define the exposure area(s) for the site. Exposure areas should be small enough to reflect an area of repeated site use by a hypothetical individual. Additional exposure areas may need to be defined for agricultural activities, including crop planting, maintenance and harvesting, and grazing.

The following recommendations for sampling have been developed to produce data that are adequate for use with the IEUBK and/or ALM. Given the primary exposure pathways (i.e., incidental ingestion of soil), the objectives of the sampling effort should include producing precise estimates of the exposure point concentration (EPC) for lead in soil. Sampling designs for outdoor shooting ranges should be appropriate for estimating the mean of skewed distributions (Cochran, 1977, p.40; Chen, 1995).Data from skeet and trap ranges indicate the distribution of lead is typically positively skewed, with concentrations in sieved samples ranging from <1 to 161,000 ppm and coefficients of skewness ranging from 1.0 to 8.3 (Dragun Corp., 1992; EA, 1994, 1995; E&E, 1997; Murray et al., 1997; TTNUS, 2001). Data from rifle and pistol ranges indicate the range of lead concentration may vary from background levels to 3.9% lead (39,000 ppm), by weight (Dragun Corp., 1992; EEA, 1992).

Sampling depth should be appropriate for the exposure scenario(s) that are to be considered in the risk assessment. Typically, this will dictate that samples be collected from the surficial soils (i.e., 0–1" depth interval) to assess current exposure scenarios. To assess the risk for future exposure scenarios it may be appropriate to also collect samples at depth. If a large number of samples from different depth intervals are planned, it is suggested to evaluate the correlation in concentration/shot density between depth intervals to determine if samples from the different depth intervals can be combined to reduce sampling costs (U.S. EPA, 2000).

Site conditions (e.g., wetlands) may restrict access to some areas of the site or may increase sampling costs. The sampling plan should account for this to avoid introducing bias into the estimate of the EPC. Samples of other media (e.g., surface water) should be collected as appropriate for the exposure scenarios considered in the risk assessment. Assistance of a statistician to develop the sampling design is recommended.

Sample Preparation. Sieving of soil samples, to evaluate risks, is recommended for two reasons: the fine particle size fraction (<250μm) is the primary source of soil ingestion (U.S. EPA, 2000) and should be used in predicting risk to humans for the incidental soil ingestion pathway; secondly, sieving will remove lead shot and large bullet fragments from the sample, which are not likely to be ingested inadvertently by humans. It is recommended that soil samples be sieved twice, first with a No. 4 (4.75 mm) or No. 10 (2.00 mm) sieve to remove bulk debris, then with a No. 60 (250μm) sieve, or smaller sieve size (U.S. EPA, 2000). The No. 4 sieve size recommendation is based on the maximum size shot that is typically used on skeet, trap, and sporting clay ranges (No. 7½), which has a diameter of 2.41 mm. Table B-1 lists the diameters of the pellets for different shot sizes and the size of the openings for different sieve sizes. The portion of the sample that passes through the No. 4 or No. 10 sieve, but retained on the No. 60 sieve, is the 'coarse fraction'; the portion passing through the No. 60 sieve is the 'fine fraction' (U.S. EPA, 2000). The portion of the sample passing through the first sieve (i.e., No. 4 or No. 10) may be referred to as the 'total' sample (i.e., coarse + fine fractions). The 'total' soil concentration may be appropriate for predicting risks to ecological receptors and for predicting risks to humans for future exposure scenarios.

It may be possible to reduce sampling costs by developing a relationship between the coarse and fine sample fractions and use the concentration in one fraction to predict the concentration in the other fraction (U.S. EPA, 2000). However, the coarse fraction will contain fragments from bullets and shot, which will tend to dominate the concentrations measured in the sample. Unless the lead fragments and shot are distributed uniformly across the site it is unlikely that the lead concentration between the coarse and fine fractions will be highly correlated. Increasing the volume of the sample or collecting composite samples may be help to improve the correlation.

Analytical Methods. Samples of the fine fraction should be analyzed for total lead to predict the risk from incidental ingestion of soil. The total fraction should analyzed for total leadto predict the risks from exposure that may occur after the bullet fragments and shot have undergone additional weathering. Solid waste test method 7421 is recommended for measuring the concentration of lead in soil when using fixed-based laboratories for analysis (EPA, 1986b). The use of field-based devices (e.g., X-ray Fluorescence [XRF]) to measure the concentration of lead may be cost-effective and decrease the time to site cleanup. EPA guidance on the use of field-based methods (U.S. EPA, 2001c) should be consulted prior to developing a sampling plan for the site.

Sample Collection at High Velocity Ranges. The horizontal boundaries of active or recently closed pistol and rifle ranges should be fairly obvious; the boundaries of pistol and rifle ranges that have been abandoned for longer periods of time may not be readily apparent from visual inspection alone. Soil samples should be collected from the berm and the rest of the shooting range(s). Samples of other media should be collected, as appropriate, given the exposure scenarios considered in the risk assessment.

Soil sample locations should be determined using random sampling methods that provide adequate coverage of the site, e.g., using systematic or stratified random sampling methods (Gilbert, 1987).

For pistol and rifle ranges, either of these sampling designs may be implemented by sampling on a rectangular or triangular grid. Jacketed bullets typically travel deeper into berms than unjacketed bullets (EA, 1996); the sampling plans for military ranges and other ranges that use jacketed bullets should take this into consideration.

Sample Collection at Low Velocity Ranges. Determining the extent of the area potentially affected by skeet and trap ranges are usually more difficult than it is for pistol and rifle ranges. This is particularly true for closed ranges. Whether the range is active or closed, records of site operations, the location of structures on the range (e.g., traphouse) and information gathered from site inspections can help to prepare a preliminary site layout upon which an initial sampling design can be based.

For skeet and trap ranges, a radial grid, with the origin located behind the shooting positions, may produce a more efficient systematic or stratified random sampling design (e.g., EA, 1995). The highest concentrations of lead are typically found in the top 6–8 inches of soil (EA, 1994, 1995; E&E, 1997;

Murray, 1997); however, elevated concentrations of lead have been detected at 24 inches below grade in skeet and trap range shotfall zones (EEA, 1992; EA, 1995; Murray, 1997).

Lead Risk Modeling Recommendations

This section provides recommendations specific to ranges. General guidance on lead risk assessment, lead models and model documentation can be downloaded from theTRW web site (U.S. EPA, 2002d). The TRW recommends the use of the IEUBK and ALM to predict risk to children and adults, respectively (U.S. EPA, 1994b, 1996). The models are intended to predict risk to humans from exposure to lead that is continuously distributed in various media, including soil.Spent lead ammunition in soil poses a potential risk to humans in two forms: 1) as lead adsorbed or absorbed to soil particles, and as very fine lead particles; and, 2) as lead adsorbed/absorbed to larger soil particles, and as lead shot and bullet fragments. Small soil particles (and by analogy, small lead particles), particularly those <250 μm in size, are the primary source of soil ingestion (EPA, 2000). Lead shot, bullets and large bullet fragments, and large soil particles contaminated with lead, are not likely to be ingested by humans, but represent a source of lead that may be released to the environment through weathering processes. The first form of spent lead ammunition should be considered under the current exposure scenario, while both forms of spent lead ammunition should be considered under future use scenarios.

The IEUBK and the ALM require the user to input an estimate for the EPC for soil; the IEUBK also provides the user with the option of inputting estimates of the EPC for other media: dust, air, drinking water, and diet (e.g., consumption of game and fish with elevated lead concentrations due to exposure to spent lead ammunition). Recommendations are limited here to providing estimates of the EPC for soil; recommendations for other media and model parameters are provided in the IEUBK User's Manual and other guidance that is available on theTRW website (U.S. EPA, 2002d) and the reference list of this paper.

Recommendations for Estimating the Exposure Point Concentration Term. When interpreting analytical data for a shooting range, it is important to distinguish between high and low velocity ranges. As described in beginning of the Site Characterization and Risk Assessment section, soil on high velocity ranges tend to contain very fine particles of lead in addition to bullets and bullet fragments. Soil on low velocity ranges will tend to contain whole and partially decomposed lead pellets. The presence of one bullet, bullet fragment, or lead shot in a soil sample will result in very high measurement of lead concentration which may not yield an accurate prediction of risk for current exposure scenarios (but may be appropriate for future exposure scenarios.

The use of geostatistics may be useful for shooting ranges, particularly skeet and trap ranges, where soil concentrations often exhibit spatial patterns. Geostatistical estimators are capable of exploiting these spatial patterns (i.e., spatial autocorrelation) to determine the extent of contaminated soil, and to produce more precise estimates of the EPC. Another advantage of geostatistical estimators is they can be used with data that have been collected by random and/or non-random sampling methods.Finally, geostatistics can take advantage of the correlation between different types of measurements (e.g., soil concentration and shot count) to obtain more precise estimates of the EPC.

Recommendations for Adjusting Bioavailability. The TRW does not recommend changing the default value for bioavailability without the collection and TRW review of good site-specific data to support such a change. Bioavailability has been shown to be related to lead speciation and soil particle size (U.S. EPA, 1999). While site specific data on lead speciation (e.g., from decomposition of spent ammunition) and particle size are not considered by EPA to be an adequate basis for adjusting the bioavailability variable in the IEUBK or ALM (U.S. EPA, 1999), this information can be used to decide if *in vivo* bioassays are likely to produce estimates of bioavailability that differ substantially from the IEUBK default value. Guidance on the bioavailability variable is available from the TRW website (U.S. EPA, 1999). Based on the available literature on lead speciation in soil on shooting ranges, it appears the default values used in the IEUBK and ALM are appropriate for assessing risks from exposure to soils located on shooting ranges.

Recommendations for Exposure Scenarios. Land use adjacent and near shooting ranges should be considered when developing current and future exposure scenarios. For currently operating sites, the populations of primary concern are residents of adjacent residential properties, residents and farm workers on adjacent agricultural properties, and workers who are employed on adjacent commercial properties. For future use scenarios, the populations of primary concern depend upon the proposed site usage.

BEST MANAGEMENT PRACTICES AND RECYCLING

Guidance for implementing best management practices on small arms outdoor shooting ranges is available from the EPA (EPA, 2001a). Implementing best management practices (BMPs) on ranges decreases the risk of spent ammunition to the environment by recycling spent ammunition; containing lead shot, bullets, and fragments; preventing migration of lead to surface water and groundwater; and keeping records of site operations (U.S. EPA, 2001a). Site conditions (e.g., wetlands, mud, steep slopes, wooded areas) will affect the feasibility of removing spent ammunition from ranges.

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Table A-1. On-line Sources of Information Related to Outdoor Small Arms Shooting Ranges

Agency/Organization	Main Web Address	Topic	Web Address
Fish and Wildlife Service	http://www.fws.gov/	Hunting information	http://birds.fws.gov/Laws.htm
		Fish and Wildlife Management Offices - State, Territorial, and Tribal	http://offices.fws.gov/statelinks.html
Environmental Protection Agency	http://www.epa.gov/	Envirosense PRO-ACT Factsheet on Lead Contamination In Soil at Small Arms Firing Ranges	http://es.epa.gov/program/p2dept/defense/airforce/2818.html
Environmental Protection Agency	http://www.epa.gov/	Military Munitions Rule, Federal Register: February 12, 1997. Volume 62, Number 29. Page 6621-6657	http://www.epa.gov/docs/fedrgstr/EPA-WASTE/1997/February/Day-12/f3218.htm
Environmental Protection Agency (EPA) - Region 2	http://www.epa.gov/	Best Management Practices for Lead at Outdoor Shooting Ranges	http://www.epa.gov/region2/waste/leadshot/
PROACT (Department of Defense)	http://www.afcee.brooks.af.mil/pro-act/PRO-ACThome.asp	Factsheet on lead contamination in soil at small arms firing ranges	http://www.afcee.brooks.af.mil/pro-act/fact/june98a.asp

Agency	Main Web Address	Topic	Web Address
Alabama Department of Conservation and Natural Resources	http://www.dcnr.state.al.us/agfd/index.html	Legal arms and ammunition for hunting	http://www.dcnr.state.al.us/agfd/arms.html
Florida Fish and Wildlife Conservation Commission	http://floridaconservation.org/	Public shooting ranges	http://floridaconservation.org/huntered/ranges.html
		Hunting information and regulations	http://www.wld.fwc.state.fl.us/hunting/default.html
Idaho Fish and Game	http://www2.state.id.us/fishgame/common/50list.htm	50 State Fish and Game Agencies List	http://www2.state.id.us/fishgame/common/50list.htm
Massachusetts Division of Fisheries, Wildlife and Environmental Law Enforcement	http://www.state.ma.us/dfwele/dpt_toc.htm	Lead shot in the environment	http://www.state.ma.us/dep/files/pbshot/pb_shot.htm
		Wildlife recreation information; hunting and fishing laws	http://www.state.ma.us/dfwele/dfw/dfwrec.htm#LAWS
Michigan Department of Environmental Quality	http://www.michigan.gov/deq/	Environmental regulations affecting shooting ranges	http://www.michigan.gov/deq/1,1607,7-135-3585_4127_13090-25492--,00.html
Ohio Environmental Protection Agency	http://www.epa.state.oh.us/	List of lead reclaimers	http://www.epa.state.oh.us/dhwm/leadrecy.htm
Tennessee Wildlife Resources Agency	http://www.state.tn.us/twra/index.html	Legal hunting equipment and methods	http://www.state.tn.us/twra/hunt001a3.html
National Shooting Sports Foundation (NSSF)	http://www.huntinfo.org/	Summaries of every state's hunting opportunities and regulations and links to state fish and game websites	http://www.huntinfo.org/

Agency	Main Web Address	Topic	Web Address
		Search page to find shooting ranges	http://www.wheretoshoot.org/
National Association of Shooting Ranges (NASR)	http://www.rangeinfo.org/	Includes references and sources of information on outdoor shooting ranges	http://www.rangeinfo.org/
National Sporting Clays Association	http://WWW.NSSA-NSCA.COM/nsca/index.htm	Search page to find shooting ranges	http://WWW.NSSA-NSCA.COM/nsca/index.htm
		Links to shooting-related sites	http://www.nssa-nsca.com/common/shooting_sites.htm
Sporting Arms and Ammunition Manufacturer's Institute, Inc. (SAAMI)	http://www.saami.org/	General source of information on shooting ranges	http://www.saami.org/
Miscellaneous	http://dir.yahoo.com/Recreation/Outdoors/Hunting/Organizations/	List of hunting organizations	http://dir.yahoo.com/Recreation/Outdoors/Hunting/Organizations/
National Wild Turkey Federation	http://www.shooting-hunting.com/index.html	search page for shooting ranges	http://www.shooting-hunting.com/results.html?Keywords=Shooting+Range

Table B-1. Shot Size and EPA-Recommended Sieve Sizes for Use at Small Arms Outdoor Firing Ranges

Shot Size	Pellet Diameter	
	Inches	Millimeters
Buckshot		
No. 000 - No. 2	.36 - .27	9.14 - 6.86
No. 3	.25	6.35
No. 4	.24	6.10
Shot		
F	.22	5.59
T	.20	5.08
BBB	.19	4.83
A NO. 4 SIEVE (0.19 INCH/4.76 MM OPENINGS) WILL REMOVE THE SHOT SIZES LISTED ABOVE.		
BB	.18	4.57
1	.16	4.06
2	.15	3.81
3	.14	3.56
4	.13	3.30
5	.12	3.05
6	.11	2.79
7	.10	2.54
7 ½	.095	2.41
8	.09	2.29
8 ½	.085	2.16
9	.08	2.03
A NO. 10 SIEVE (0.08 INCH/2.00 MM OPENINGS) WILL REMOVE THE SHOT SIZES LISTED ABOVE		
A NO. 60 (0.25 MM OPENINGS) SIEVE, OR SMALLER SIEVE SIZE, IS RECOMMENDED TO PREPARE THE 'FINE' SOIL FRACTION FOR ANALYSIS (SEE 'SAMPLE PREPARATION' SECTION)		

Note: Shot size is generally limited to a maximum of no. 7½ for trap and sporting clay use, and a maximum of no. 7 ½ and minimum of no. 9 for skeet shooting.

United States
Environmental Protection
Agency

EPA-902-B-01-001
Revised June 2005
Region 2

Best Management Practices for Lead at Outdoor Shooting Ranges

For additional copies of this manual, please contact:

United States Environmental Protection Agency
Division of Enforcement and Compliance Assistance
RCRA Compliance Branch
290 Broadway, 22nd Fl.
New York, New York 10007-1866

Tel: 212-637-4145
Fax: 212-637-4949

Copies of this manual along with any additions or updates can also be obtained on-line at:
http://www.epa.gov/region2/waste/leadshot

Copying and Reprinting

Fourth Printing, June 2005

Best Management Practices for Lead at Outdoor Shooting Ranges

Notice

This manual is intended to provide useful general information to shooting range owners/operators. The United States Environmental Protection Agency (EPA) does not certify or approve ranges, range design or lead management practices. While every effort has been made to provide up-to-date technical information, this manual is not to be used as a substitute for consultation with scientists, engineers, attorneys, and other appropriate professionals who should be called upon to make specific recommendations for individual range design and lead management.

Any variation between applicable regulations and the summaries contained in this guidance document are unintentional, and, in the case of such variations, the requirements of the regulations govern.

This guidance was developed by EPA Region 2 in cooperation with a few states as well as many EPA offices. In addition, EPA, with the assistance of the Association of State and Territorial Solid Waste Management Officials (ASTSWMO) provided all 50 states with an opportunity to review the RCRA regulatory portion of the guidance. At the time of printing, about 40 states had contacted the EPA and given their support and concurrence. EPA is continuing to get the agreement of the remaining states. Therefore, it appears that most, if not all, states will share the same view as to how lead shot is regulated.

Following the steps set forth in this guidance should result in compliance with applicable regulations. EPA does not make any guarantee or assume any liability with respect to the use of any information or recommendations contained in this document.

This guidance does not constitute rulemaking by the EPA and may not be relied on to create a substantive or procedural right or benefit enforceable, at law or in equity, by any person.

Acknowledgements

The USEPA would like to acknowledge the support of:

- The National Rifle Association of America
- The National Shooting Sports Foundation
- The Wildlife Management Institute
- Mark Begley of the Massachusetts Department of Environmental Protection
- Mr. Dick Peddicord of Dick Peddicord and Company, Inc.

These participants provided valuable information and assistance as peer reviewers in the development of the manual and their efforts are truly appreciated. EPA also wishes to give special thanks to Dr. Charles W. Sever of Okie Environmental Consulting, L.L.C., Inc., Mr. Mike Warminsky of Brice Environmental Services Corp., and Mr. Victor Ordija of Sporting Goods Properties.The EPA also wishes to acknowledge and thank the many others who provided important comments and insight, and especially those individuals who took the time to meet with us in person or on the phone.

Cover photo by: Mr. Jack Hoyt, EPA Region 2

Statement of Goals

The goals of this manual are:

- to inform shooting ranges :
    - that the United States Environmental Protection Agency's (EPA) purpose in developing and distributing this manual is to assist range owners and operators to operate in an environmentally protective .manner.
- to promote an understanding of:
    - why lead is an environmental, public and regulatory concern,
    - what laws and regulations apply,
    - the benefits of applying good management practices,
    - what can be done to successfully manage lead,
    - why implementing lead best management practices is an integral part of environmental stewardship,
    - how to minimize litigation risk.
- to promote action by ranges to:
    - adopt and implement best management practices for managing lead,
    - recycle a finite natural resource,
    - become a model for other ranges through proper lead management,
    - advocate environmental stewardship.

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EPA Statement on National Guidance

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OCT 10 2001

OFFICE OF
SOLID WASTE AND EMERGENCY
RESPONSE

MEMORANDUM

SUBJECT: National Guidance on Best Management Practices for Lead at Outdoor Shooting Ranges

FROM: Elizabeth A. Cotsworth, Director
Office of Solid Waste

TO: RCRA Senior Policy Advisors

The purpose of this memo is to transmit a Region 2 document entitled "Best Management Practices for Lead at Outdoor Shooting Ranges," EPA-902-B-01-001, January 2001. This report is a technical information manual to assist range owners and operators in managing lead at shooting ranges. The report covers the environmental concerns, applicable laws and regulations, and current best management practices. This document was developed collaboratively with a number of stakeholders and is considered by my office to be the national guidance on this subject.

Background

Lead at some shooting ranges can be a significant environmental concern depending on location (e.g., proximity to wetlands) and hydrogeologic setting, as evidenced by a number of cases where lead pellets and shot have been taken in by fish and fowl at ranges over wetlands, and at some ranges where streams in acid lead-leaching environments have picked up lead contamination. Recognizing these problems, Region 2 in collaboration with EPA HQ, States, shooting range associations, and other shooting range experts, developed the enclosed technical guidance to identify the problems and solutions for preventing and controlling these problems. We commend this guidance to you as an information source for your use in working with range owners and operators to identify and address these concerns at specific ranges. Copies of this manual have been sent to all 50 States, with the help of ASTSWMO, and at least 40 States have responded with concurrence and support for this guidance.

Also enclosed for your information is a list of references "Summary of Shooting Range Lead Management Guidance" prepared by various shooting range-interested associations, and a copy of an NPDES permit for the Naperville, IL Sportsman's Park shooting range.

If you have any questions regarding lead at shooting ranges, please contact George Meyer (Chief, RCRA Compliance Branch, Region 2) at 212-637-4144, Meyer.George@epa.gov, or Ken Shuster in the Office of Solid Waste at 703-308-8759, shuster.kenneth@epa.gov.

It is my hope that wide distribution of these documents will help encourage greater cooperation and coordination on shooting range issues among RCRA, Superfund, and Water staff in the regions and states. To this end, it would be helpful if you would send the name of a point of contact in your region to Ken Shuster and George Meyer.

For additional copies of the Region 2 guidance, please contact George Meyer. It is also available at www.epa.gov/region2/waste/leadshot.

Enclosures

cc: George Meyer, Region 2
Elaine Davies, OERR
Michael Cook, OW
Eric Schaeffer, ORE, OECA
Craig Hooks, FFEO, OECA
Bob Byrne, Wildlife Management Institute
Barbara Simcoe, ASTSWMO
Regional Superfund Division Directors w/o Region 2 enclosure
Regional Water Division Directors w/o Region 2 enclosure
Regional RCRA Enforcement Section Chiefs w/o Region 2 enclosure

Best Management Practices for Lead at Outdoor Shooting Ranges

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Introduction

This manual provides owners and operators of outdoor rifle, pistol, trap, skeet and sporting clay ranges with information on lead management at their ranges. This manual serves as a reference guide and presents best management practices (BMPs) available to the shooting range community. The practices have been proven to effectively reduce or eliminate lead contamination and may also be economically beneficial to the range owner/operator. Since each range is unique in both the type of shooting activity and its environmental setting, specific solutions are not provided in this manual. Rather, a range owner or operator may use this manual to identify and select the most appropriate BMP(s) for their facility. Other information on environmental aspects of management at outdoor shooting ranges can be found in the National Shooting Sports Foundation's *Environmental Aspects of Construction and Management of Outdoor Shooting Ranges.*

The manual does not address range layout or design to meet range safety or competition requirements. For information on range safety and competition requirements, range owners/operators are directed to other comprehensive reference materials available on that subject, such as the National Rifle Association's *Range Source Book,* and the National Association of Shooting Range's website (www.rangeinfo.org).

Owners/operators of ranges may want to assign the use of this BMP Manual to a specific team or committee. Delegating this responsibility to a specific team or group helps to assure that the BMP's are identified and implemented.

The manual is organized as follows:

- Chapter I provides the background on why lead is of concern to human health and the environment. It includes a discussion of how environmental laws impact shooting ranges and the importance of an integrated BMP program to manage lead.
- Chapter II discusses physical and operational characteristics to be considered when selecting a successful BMP program.
- Chapter III addresses best management techniques for rifle/pistol ranges, skeet and trap ranges, and sporting clay ranges. In this chapter, the manual explores possible solutions to prevent, reduce and/or remove lead contamination for each type of range.
- The Appendices provide current (as of June 2005) contacts for lead reclamation and recycling companies, vendors that provide prevention and/or remediation techniques and shooting organizations that have additional information on the lead issue. Additionally, the Appendices provide information on alternatives to lead, diagrams of bullet trap designs, summaries of regulatory requirements and interpretations, and a sample Environmental Stewardship Plan.

EPA is very interested in any suggestions you have about practices included in this manual which have proven effective in controlling lead contamination or recycling lead bullets/shot. Please send such information to the address below. Also, for additional information, or to be added to the list of lead reclaimers or remediation contractors, contact the National Rifle Association (NRA), the National Shooting Sports Foundation (NSSF) or:

Lead Shot Coordinator
RCRA Compliance Branch
U.S. Environmental Protection Agency
Region 2
290 Broadway
New York, New York 10007-1866
Telephone: (212)637-4145
E-Mail: Leadshot.Region2@epa.gov

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Chapter I: Environmental and Regulatory Concerns at the Shooting Range

1.0 Background

Outdoor shooting ranges provide recreational facilities for millions of shooting sports enthusiasts in the United States. Recently, there has been a growing public concern about the potential negative environmental and health effects of range operations. In particular, the public is concerned about potential risks associated with the historical and continued use of lead shot and bullets at outdoor ranges.

This concern is not unfounded. An estimated 9,000 non-military outdoor ranges exist in the United States, collectively shooting millions of pounds of lead annually. Some ranges have operated for as long as several generations. Historical operations at ranges involved leaving expended lead bullets and shot uncollected on ranges. Many of these ranges continue to operate in the same manner as in the past.

It is estimated that approximately four percent (4%) (80,000 tons/year) of all the lead produced in the United States in the late 1990's (about 2 million tons/year), is made into bullets and shot. Taking into account rounds used off-range, and rounds used at indoor ranges, it is clear that much of this 160,000,000 pounds of lead shot/ bullets finds its way into the environment at ranges.

Since the mid-1980's, citizen groups have brought several lawsuits against range owners and have urged federal and state agencies to take action against owners and operators of outdoor shooting ranges. The citizen groups argued that range owners improperly managed discharged lead bullets and shot. Federal courts have supported parts of these suits, requiring range owners/operators to clean up lead-contaminated areas. Concurrent with the increased citizen suit activity, the federal EPA, the Centers for Disease Control and Prevention (CDCP), and a large number of states have identified human exposure to all forms of lead as a major health concern in the United States.

Lead management practices at ranges across the United States remain inconsistent. Some range owners/operators have examined the impact of range operations on human health and the environment and have implemented procedures to manage and/or remove accumulated lead from ranges. Other range owners/operators are just beginning to characterize and investigate their ranges in order to design an environmental risk prevention and/or remediation program(s) specific to their sites. A third group of ranges has adopted a "wait and see" policy – taking no action until specifically required to do so by law or clear guidance is in place. Finally, a fourth, small, but important group of range owners/operators remain unaware of lead's potential to harm human health and the environment, and of existing federal and state laws.

To manage lead, many owners and operators have successfully implemented Best Management Practices (BMPs) at their ranges. These range owners and operators have realized many benefits from sound lead management including:

- stewardship of the environment, natural resources and wildlife,
- improved community relations,
- improved aesthetics of the range/good business practices,
- increased profitability through recovery/ recycling lead, a valuable and finite resource, and
- reduced public scrutiny.

Shooting sports organizations [e.g., National Rifle Association (NRA) and the National Shooting Sports Foundation (NSSF)] promote lead management throughout the United States. These organizations have researched different methods to effectively address potential and actual lead mobility and exposure without detracting from the enjoyment of the sport. The NRA, NSSF, and a number of other shooting sports organizations strongly encourage range owners/operators to develop a BMP program that contains elements discussed later in this manual. Contact the NRA and NSSF for additional guidance materials available on lead management practices.

By implementing appropriate lead management at outdoor shooting ranges, range owners and operators can reduce the environmental and health risks associated with lead deposition, meet legal requirements and realize quantifiable benefits.

1.1 Lead Contamination's Impact on Human Health and the Environment

Exposure Routes

Historically, the three major sources for human exposure to lead are lead-based paint, lead in dust and soil and lead in drinking water. Typically, human exposure occurs through ingestion, which is the consumption of lead or lead-contaminated materials, or by inhalation. The main human exposure to lead associated with shooting ranges is through lead-contaminated soil. However, other pathways are discussed below, along with lead's detrimental effects on humans and animals.

Lead can be introduced into the environment at shooting ranges in one or more of the following ways. Each of these pathways is site-specific and may or may not occur at each individual range:

- Lead oxidizes when exposed to air and dissolves when exposed to acidic water or soil.
- Lead bullets, bullet particles, or dissolved lead can be moved by storm water runoff.
- Dissolved lead can migrate through soils to groundwater.

<u>Lead oxidizes when exposed to air and dissolves when exposed to acidic water or soil</u>

When lead is exposed to acidic water and/or soil, it breaks down by weathering into lead oxides, carbonates, and other soluble compounds. With each rainfall, these compounds may be dissolved, and the lead may move in solution in the storm runoff waters. Decreases in water acidity (i.e., increases in its pH) will cause dissolved lead to precipitate out of solution. Lead concentrations in solution are reduced by this precipitation. At pHs above 7.5, very little lead remains in solution. Increased time of contact between lead and acidic water generally results in an increase in the amount of dissolved lead in the storm runoff water. The five factors which most influence the dissolving of lead in water are summarized below:

Annual Precipitation Rate - The higher the annual precipitation rate, the faster the lead weathers. Also, during prolonged rains, the contact time between water and lead is increased. In general, the higher the precipitation rate, the higher the potential risk of lead migration off-site in solution.

pH of Rain and Surface Water - The acidity of the rainwater decreases as basic (alkaline) minerals in the soil are dissolved. If sufficient minerals such as calcium, magnesium, and iron are present in local soils, then the lead may quickly precipitate out of solution entirely as these other minerals are dissolved. The pH of shallow surface water is an indicator of the presence or absence of basic minerals in the local soil and in gravel within the stream beds through which the water has moved. The water in deeper streams and lakes is more likely to be composed of acidic rainwater that is not neutralized.

Contact Time - The contact time between acidic surface water and lead is a factor in the amount of lead that is dissolved. For example, lead shot deposited directly into a lake has a longer contact time then lead shot deposited in upland areas.

Soil Cover - Organic material will absorb lead and remove it from a water solution. The thicker the organic leaf and peat cover on the soil, the lower the lead content in solution in water leaving the shot area. Organic material has a strong ability to extract lead out of solution in water.

pH of Groundwater - During periods of no rainfall, the water flowing within most streams comes from groundwater discharging into the stream channel. Therefore, the acidity of the groundwater affects the acidity of the surface water, and hence, affects the solubility of any lead particles carried into the stream during storm runoff.

<u>Lead bullets, bullet particles or dissolved lead can be moved by storm water runoff</u>

The ability of water to transport lead is influenced by two factors: velocity of the water and weight or size of the lead fragment. Water's capacity to carry small particles is proportional to the square of the water's velocity. Clear water moving at a velocity of 100 feet per minute can carry a lead particle 10,000 times heavier than water moving at a velocity of 10 feet per minute. Muddy water can carry even larger particles. The five factors that most influence velocity of runoff are described below:

Rainfall Intensity - The greater the volume of rainfall during a short period of time, the faster the velocity created to carry the rainfall off-site. The higher the annual rainfall, the greater the number of periods of heavy rainfall.

Topographic Slope - Generally, the steeper the topographic slope, the faster the velocity of stormwater runoff.

Soil Type - More rainfall will soak into sandy soils then into clay soils. Hence, for a given rainfall intensity, the volume of runoff will be greater from areas underlain by clays or other low permeable soils than from permeable sandy soil.

Velocity - Velocity tends to decrease as stream width increases. Merging streams, eddy currents, and curves in streams are other factors that may reduce the velocity. Generally, the shorter the distance from the lead deposit to the property line, the more likely it is that the lead fragments in suspension will be transported off-site.

Vegetative Cover and Man-made Structures - Structures such as dams and dikes reduce the water's velocity and greatly reduce the size and weight of the lead particles the water can carry. Since lead particles are heavy compared to the other suspended particles of similar size, they are more likely to be deposited under the influence of anything that reduces velocity of the storm runoff. Grass and other vegetation reduce runoff velocity and act as a filter to remove suspended solids from the water.

<u>Dissolved lead can migrate through soils to groundwater</u>

Acidic rainwater may dissolve weathered lead compounds. A portion of the lead may be transported in solution in groundwater beneath land surfaces. Groundwater may transport lead in solution from the higher topographic areas to the lower areas such as valleys, where it is discharged and becomes part of the surface water flow. If the water flowing underground passes through rocks containing calcium, magnesium, iron, or other minerals more soluble then lead, or through minerals that raise the pH of the water, then the lead in solution may be replaced (removed) from the solution by these other metals. However, if the soil is a clean silica sand and gravel, fractured granite, or similar type material, then the lead may move long distances in solution. The factors most likely to affect the amount of lead carried by the groundwater in solution are discussed below:

Annual Precipitation - Generally, high precipitation rates result in heavy dew, more frequent rainfall, numerous streams, shallow depth to groundwater, shorter distance of travel, and more rapid rates of groundwater flow. Also, the greater volumes of rainfall over geologic time probably have reduced the amount of calcium and other soluble basic minerals that could raise the water pH and cause lead to precipitate (settle) out of solution from the groundwater.

Soil Types - Clays have a high ionic lead bonding capacity and more surface area to which the lead can bond. Also, groundwater movement in clay is very slow, which increases the contact time for lead to bond to the clay.

Low permeability reduces the amount of historical leaching and increases the probability of the presence of basic (pH-increasing) minerals that can precipitate out of solution in groundwater or cause the lead to bond to the clay. All of the basic calcium and related minerals generally will have been removed from the clean silica sand and gravel soils, so the lead in solution in groundwater in these type soils can move long distances (miles) through the ground relatively unchanged.

Soil Chemistry - The more basic minerals like calcium and magnesium that are present in soils along the pathways through which the groundwater moves, the greater the lead precipitation (removal) rate. Lead should move in solution only a short distance (a few feet) through a sand composed of calcium shell fragments, but could move in solution long distances (miles) through clean quartz sand.

Depth to Groundwater - In areas of groundwater discharge such as river flood plains and most flat areas, the groundwater surface is often a few feet below the surface. Remember, the shorter the distance traveled, the greater the risk that the lead will migrate into the environment. Shallow depth to groundwater is indicative of higher risk for lead to reach the water.

pH of Groundwater - Although other factors influence solubility of lead in water, a good rule of thumb is that lead will precipitate out of solution when the pH or alkalinity of water is greater then about 7.5. But, lead dissolved in acid groundwater may travel many miles without change.

Health Effects of Lead Exposure on Ranges

Lead poisoning is a serious health risk. At higher concentrations, it is dangerous to people of all ages, leading to convulsions, coma and even death. At even very low concentrations, it is dangerous to infants and young children, damaging the developing brain and resulting in both learning and behavioral problems. Figure 1-1 describes the effects of exposure to lead on children and adults.

Federal, state and local actions, including bans on lead in gasoline, paint, solder and many other lead-containing products, have resulted in significant reductions in average blood-lead levels. Despite these advances, the number of lead-poisoned children remains alarmingly high. Children living in older homes may be exposed to lead in peeling paint or paint dust. Children can also come in contact with lead in soil and with lead dust carried home on the clothing of parents.

On ranges, inhalation is one pathway for lead exposure since shooters are exposed to lead dust during the firing of their guns. Because wind is unlikely to move heavy lead particles very far, airborne dust is generally considered a potential threat only when there are significant structures that block air flow on the firing line. Under such conditions, the hygiene and other practices proposed by the NRA for indoor shooting ranges in their "Source Book" are applicable to outdoor ranges.

Range workers may also be exposed to lead dust while performing routine maintenance operations, such as raking or cleaning out bullet traps. Owners/operators may want to protect these workers by requiring them to wear the proper protective equipment or dampening the soil prior to work.

Another exposure route for lead at outdoor ranges is ingestion by direct contact with lead or lead particles. For example, lead particles generated by the discharge of a firearm can collect on the hands of a shooter. These particles can be ingested if a shooter eats or smokes prior to washing his/her hands after shooting. **The relative risk of lead exposure to people in a well managed facility is low.**

Detrimental effects due to elevated lead levels can also be found in animals. Excessive exposure to lead, primarily from ingestion, can cause increased mortality rates in cattle, sheep and waterfowl. For example, waterfowl and other birds can ingest the shot, mistaking it for food or grit. Waterfowl, in particular, are highly susceptible to lead ingestion. This is a concern at ranges where shooting occurs into or over

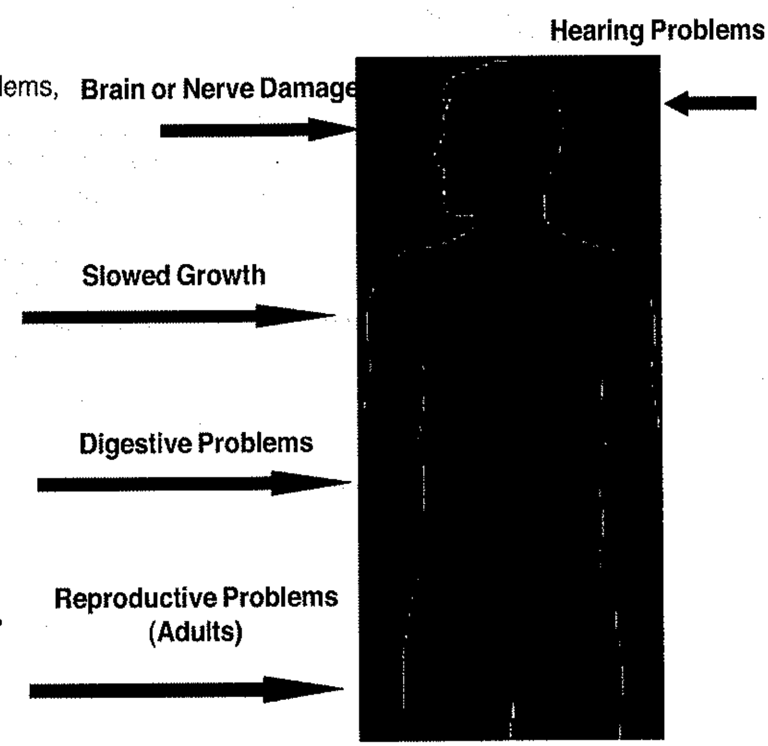
Effects on the Human Body from Excessive Exposure to Lead

If not detected early, **children** with relatively low levels of lead (as low as 10 microgram/deciliter for children) in their bodies can suffer from:

- damage to the brain and nervous system,
- behavior and learning problems (such as hyperactivity and aggressiveness),
- slowed growth,
- hearing problems,
- headaches, and
- impairment of vision and motor skills.

Adults can suffer from:

- difficulties during pregnancy,
- reproductive problems in both men and women (such as low birth weight, birth defects and decreased fertility),
- high blood pressure,
- digestive problems,
- neurological disorders,
- memory and concentration problems,
- muscle and joint pain, and
- kidney dysfunction.



Lead affects the body in many ways

Figure 1-1: Effects on the Human Body from Excessive Exposure to Lead

water. Many of the legal and government actions that have been brought against ranges are based on elevated levels of lead and increased mortality in waterfowl. For example, in one case, an upland area of a range became a temporary pond after a thunderstorm. Waterfowl used the pond to feed and shortly thereafter, there was a waterfowl die-off (increase in bird mortality), apparently from lead ingestion.

1.2 Legal Requirements & Court Rulings

To date, most litigation concerns have been at shotgun ranges where the shotfall zone impacts water or wetland areas. The potential environmental and human health risks are greater at these ranges. However, all ranges, including those not located near water bodies, may be subject to legal and government action if proper range management programs are not implemented. Range owners/operators should expect greater scrutiny as ranges become more visible to regulators, environmental groups and the general public.

Citizen groups have been the driving force behind most legal actions taken against outdoor ranges. These groups have sued range owners/operators under federal environmental laws. Two of EPA's most comprehensive environmental laws, the Resource Conservation and Recovery Act (RCRA) and the Clean Water Act (CWA), specifically provide citizens with the right to sue in cases in which the environment and human health are threatened. These citizen suits have been highly effective in changing the way ranges operate, even when out-of-court settlements have been reached. The decisions of the United States Court of Appeals for the Second Circuit in *Remington Arms* and *New York Athletic Club* set a legal precedent in the application of RCRA and/or the CWA to outdoor ranges. Lead management programs at outdoor ranges must comply with both laws. Actions have also been taken under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) commonly know as Superfund. State and local statutes and regulations may also apply. To ensure environmental laws are being followed, range owners/operators must understand the legal issues and requirements.

1.2.1 Resource Conservation and Recovery Act (RCRA)

RCRA provides the framework for the nation's solid and hazardous waste management program. Under RCRA, EPA developed a "cradle-to-grave" system to ensure the protection of human health and the environment when generating, transporting, storing, treating and disposing of hazardous waste. RCRA potentially applies to many phases of range operation because lead bullets/shot, if abandoned, may be a solid and/or a hazardous waste and may present an actual or potential imminent and substantial endangerment.

Connecticut Coastal Fishermen's Association v. Remington Arms Company, et al.

In the late 1980s, the Connecticut Coastal Fishermen's Association filed a lawsuit against Remington Arms Company as the owner of the Lordship Gun Club. The Lordship Gun Club (a.k.a. Remington Gun Club) is a 30-acre site in Stratford, Connecticut, located on the Long Island Sound at the mouth of the Housatonic River. In the mid-1960s, the Lordship Gun Club was reconstructed to its final configuration of 12 combined trap and skeet fields and one additional trap field. Over the years, the Lordship Gun Club became known as one of the premier shooting facilities on the East Coast.

The Connecticut Coastal Fishermen's Association filed a lawsuit, alleging that lead shot and clay targets are hazardous waste under RCRA. The Complaint alleged that because the lead shot and clay targets were hazardous wastes, the gun club was a hazardous waste storage and disposal facility subject to RCRA requirements. The plaintiff also sought civil penalties and attorney's fees.

Remington moved for a summary judgment dismissing the complaint, and the Connecticut Coastal Fisherman's Association cross-moved for a partial summary judgment on the issue of liability. On September 11, 1991, the United

States District Court for the District of Connecticut ruled on the case.

Regarding the plaintiff's claims under RCRA, the District Court ruled in favor of the Connecticut Coastal Fishermen's Association, holding that the lead shot and clay targets were "discarded materials" and were "solid waste;" therefore, the materials were subject to regulation under RCRA. The court further stated that the discharged lead shot was a "hazardous waste," but declined to rule on whether the clay target fragments were also hazardous waste. Remington petitioned the United States Court of Appeals for the Second Circuit Court to review the lower court's ruling.

On June 11, 1992, both parties presented oral arguments before the court. Subsequent to oral arguments, the appellate court requested that EPA file an amicus brief "addressing whether lead shot and clay target debris deposited on land and in the water in the normal course of trap and skeet shooting is 'discarded material'... so as to constitute 'solid waste' under RCRA."

On March 29, 1993, the United States Court of Appeals for the Second Circuit reached its decision. With respect to RCRA, the court both reversed and affirmed the lower court's opinion in part.

Briefly, the decision affects currently operating and future gun clubs, and the following key points are of primary concern:

1. With respect to RCRA, the court agreed with EPA's amicus brief, which had argued that shooting at gun clubs is not subject to regulatory (as opposed to statutory) requirements. In other words, during routine operations, gun clubs are not viewed as facilities that manage hazardous wastes subject to RCRA regulations and, as such, do not require RCRA permits.

2. Another argument in the EPA's amicus brief with which the court agreed was the view that the RCRA statute allows citizen suits to be brought if a gun club's shooting activities pose an "imminent and substantial endangerment to health or the environment." Although gun clubs are not subject to RCRA regulations, EPA or any state, municipality, or citizen group can take legal action under the statutory provisions of RCRA against gun clubs for actual or potential environmental damage occurring during, or even after, the operation of the club. Under RCRA, the plaintiff would be eligible to recover its legal fees as well.

3. The court concluded that lead shot and clay targets meet the statutory definition of solid waste because these materials were "discarded (i.e. abandoned)" and "left to accumulate long after they have served their intended purpose." Further, the court concluded that based upon toxicity testing and evidence of lead contamination, the lead shot was a hazardous waste subject to RCRA.

The important point to consider here is that if lead shot and clay target debris are discarded (i.e. abandoned), these materials are considered a solid waste as defined in the statute and the facility may be subject to governmental or citizen suits.

If, on the other hand, the discharged lead shot is recovered or reclaimed on a regular basis, no statutory solid waste (or hazardous waste) would be present and imminent hazard suits would be avoided.

Thus, the Remington Arms case is an important legal precedent. Even though regulations have not been issued regarding gun club operations and environmental protection, gun clubs are still at risk of legal action under RCRA if they fail to routinely recover and reclaim lead, do not take steps to minimize lead release or migration, or if they abandon lead in berms.

Gun clubs where there is shooting into water, wetlands, rivers, creeks, and other sensitive environments have the highest degree of litigation risk. Conversely, gun clubs that have the lowest risk of environmental litigation or government action are those clubs that do not shoot into water or wetlands and which have an active program to recover lead.

The following describes how RCRA may apply to outdoor shooting ranges.

How is Lead Shot Regulated Under RCRA?

Lead shot is not considered a hazardous waste subject to RCRA at the time it is discharged from a firearm because it is used for its intended purpose. As such, shooting lead shot (or bullets) is not regulated nor is a RCRA permit required to operate a shooting range. However, spent lead shot (or bullets), left in the environment, is subject to the broader definition of solid waste written by Congress and used in sections 7002 and 7003 of the RCRA statute.

With reference to reclaiming and recycling lead shot, the following points should serve as guidance in understanding RCRA and how it applies to your range. (A more detailed discussion of the underlying RCRA rules applicable to lead shot removal at ranges is included in Appendix D)

- **Removal contractors or reclaimers should apply standard best management practices, mentioned in this manual, to separate the lead from soil. The soil, if then placed back on the range, is exempt from RCRA. However, if the soil is to be removed off-site, then it would require testing to determine if it is a RCRA hazardous waste.**

- **Lead, if recycled or reused, is considered a scrap metal and is, therefore, excluded from RCRA.**

- Collected lead shot and bullets are excluded from RCRA regulation, and need not have a manifest, nor does a range need to obtain a RCRA generator number (i.e., the range is not a hazardous waste "generator"), provided that the lead is recycled or re-used. The reclaimer does not need to be a RCRA transporter. **However, it is recommended that ranges retain records of shipments of lead to the receiving facilities in order to demonstrate that the lead was recycled. Records should also be kept whenever the lead is reused (as in reloading.) The range should be aware that it ultimately may be responsible for the lead sent for reclamation. Therefore, only reputable reclaimers should be utilized.**

- Lead from ranges destined for recycling may be temporarily stored on range property after separation from soil if the lead is stored in closed, sealed containers, the containers are stored in a secure location and routinely inspected by range staff, and records of inspections are maintained.

- Sections 7002 and 7003 of the RCRA statute allow EPA, states or citizens to use civil lawsuits, to compel cleanup of or other action for "solid waste" (e.g., spent lead shot) posing actual or potential imminent and substantial endangerment. Such actions can be sought whether the range is in operation or closed, and is based solely on a determination that harm is being posed or may be posed by the range to public health and/or the environment. Since the risk of lead migrating increases with time, making ranges that have not removed lead more likely candidates for government action or citizen lawsuits under RCRA Section 7002 and 7003, ranges are advised to maintain a schedule of regular lead removal.

- With time, lead in soil can become less desirable to reclaimers and smelters, thereby potentially reducing or eliminating financial returns from lead removal. Moreover, such soil may be subject to more expensive treatment to separate the lead for recycling.

- Lead removal will allow the range to: avoid contamination of the site and potential impacts to human health and the environment; reduce liability with regard to potential government agency or citizen suit action; and, possibly, benefit economically from the recycling of lead. Additional guidance on reclaiming lead is provided in other parts of this manual.

- Soil from berms and shotfall zones may be moved to another area of the range for such reasons as addressing potential environmental impacts (e.g., runoff), altering the layout to address safety concerns or allowing different types of shooting activities, or adding or removing shooting positions. However, removal of lead prior to such movement of soil is normal practice and highly advised because it extends the usable life of the materials and reduces the possibility of release of lead into the environment. If lead is not first removed, it will be further dispersed and will be more difficult to remove in future reclamation. Written records of all such activity should be maintained indefinitely, as they will be necessary in subsequent construction or range closure.

- This RCRA summary applies to operating and non-operating ranges, and the use of BMPs at operating ranges is highly recommended. However, because of increased risk if lead is not actively managed, such application may not preclude the need for remediation, as appropriate and/or as required by states' regulations, when a range is permanently closed, on-site lead is abandoned, or the land use changes. Introductory guidance for remediation can be found at www.epa.gov/epaoswer/osw or www.epa.gov/superfund. Look under the sections "Cleanup" or "Resources," or use the Search function.

1.2.2 - Clean Water Act

The goal of the Clean Water Act (CWA) is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The most common allegation against ranges by the EPA and citizen groups, is that they violate the CWA if they do not have permits that allow spent ammunition to be discharged into water. The CWA prohibits "the discharge of any pollutant by any person" into the waters of the United States without a National Pollution Discharge and Elimination System (NPDES) permit. There have been two court cases that have applied the provisions of the CWA to civilian shooting ranges. To understand how the CWA can apply to shooting ranges, a summary of the cases follows. Also see Table 1-1.

To understand the application of the CWA to outdoor ranges, one must know the definitions of key terms and how they have been applied to shooting activities. See Table 1-1.

In the *Remington Arms* and the *New York Athletic Club* lawsuits, citizen groups argued that the defendants violated the CWA by discharging pollutants from point sources into the Long Island Sound without a NPDES permit. Application of the CWA requires the violations to be ongoing. Consequently, the court in *Remington Arms* dismissed the CWA charge against the range because it had ceased operating before the lawsuit was filed.

However, in the *New York Athletic Club* case, the club was still in operation during the time of litigation, but had switched to steel shot. EPA's opinion on this case also addressed the CWA violation. EPA argued that certain trap/skeet ranges can convey pollutants, via point sources, to water in violation of the CWA if a NPDES permit is not obtained. Although some shooting organizations have disagreed with the EPA position, the United States District Court for the Southern District of New York specifically found that:

- The mechanized target throwers, the concrete shooting platforms, and the shooting range itself are considered point sources as defined by the CWA;

- Expended shot and target debris, including non-toxic shot, such as steel shot, left in water, are pollutants as defined by the CWA.

Although the New York district court's decision in the *New York Athletic Club* case is not controlling in any other district, range owners and operators of outdoor ranges that shoot over or into wetlands or other navigable waters of the United States should be aware of it.
Based on the court's decision in the *New York Athletic Club* case, any range whose shot, bullets or target debris enter the "waters of the United States" could be subject to permitting requirements as well as governmental or citizen suits. "Waters of the United States" or "navigable waters of the United States" are waters of the United States, including territorial seas that include any body of water that has any connection to, or impact on, interstate waters or commerce. The waters may include lakes,

Table 1-1: Application of Key Terms to Outdoor Ranges

Key Term	Statutory Definition	Application to *New York Athletic Club*
Discharge of a Pollutant	"any *addition* of any pollutant to navigable waters from any point source" (emphasis added) 33 U.S.C. § 1362 (12)	Shooting into water (including wetlands) constitutes a discharge. In the *New York Athletic Club*, the range did not dispute that its shooting operations resulted in the deposition of spent shot and other debris into the waters of the United States.
Point Source	"any discernible, confined, and discrete conveyance... from which pollutants are or may be discharged" into the Nation's waters. 33 U.S.C. § 1362 (14)	In *New York Athletic Club*, the court found that shooting ranges act to systematically channel pollutants into regulated waters and that mechanized target throwers convey pollutants directly into water. Specifically, it stated, "A trap shooting range... is an identifiable source from which spent shot and target fragments are conveyed into navigable waters of the United States." The court also determined that the concrete shooting platforms can be seen as separate "point sources" under the CWA or as one facet of the shooting range that systematically delivers pollutants (e.g. shot and wadding) into the water.
Pollutant	"dredged spoil, solid waste,... munitions... discharged into water" 33 U.S.C. § 1362 (6)	In *New York Athletic Club*, shot and target residue constitute a form of "solid waste" subject to regulation under the CWA as a "pollutant." Based on these determinations, the court supported EPA's contention that the ranges were discharging pollutants from a point source without a permit, in violation of the CWA.

ponds, rivers, streams, wetlands, or even guts that are frequently dry, which may not be obvious to range owners/operators. These ranges may be required to remediate contaminated sediments and soils, which could be both difficult and expensive, and to cease operations over waters and wetlands. **It is essential that these ranges change the direction of shooting, to avoid shooting over or into wetlands or other navigable waters of the United States, and initiate lead removal and recycling activities, where feasible.**

In addition, these ranges can cause a substantial impact on wildlife and wetlands, which range owners/operators may be required to restore under other federal laws (e.g., CERCLA, discussed below). Lead shot entering a water body substantially increases the potential risk of contaminating surface and groundwater which, in turn, threatens human health and the environment. Finally, as *New York Athletic Club*, *Remington Arms* and similar cases show, neighbors have the most leverage when range activity affects wetlands and waterways.

For ranges located away from coastal areas or whose operating areas are situated wholly over land, compliance with the CWA can be achieved by obtaining a NPDES permit for piped or channeled runoff from the range into water[1].

Shooting ranges impacting wetland areas may be subject to other regulations found in Section 404 of the CWA. This section is the principal federal regulatory program protecting the Nation's remaining wetland resources. Any plan by range owners/operators to dredge and/or fill wetlands may require a permit and will come under close scrutiny by federal, state and local governments and citizen groups. Owners and operators must comply with the CWA for range design, redesign, construction, reclamation or remediation occurring in wetland areas.

[1] The term "land" in this instance refers specifically to terrain recognized as "non-wetland" areas.

1.2.3 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), imposes liability on past and present owners or operators of properties where a release of a hazardous substance into the environment exists. CERCLA is used to ensure that an owner/operator cleans a contaminated site or to seek reimbursement from past owners/operators or disposers (potentially responsible parties or PRPs) when a party, either the government or private party, has cleaned up the contamination. Under CERCLA, lead is considered a hazardous substance.

EPA has the authority to order a PRP to clean up a site or conduct the cleanup and recover its costs from the PRP under CERCLA. Responsible parties may be held liable for all cleanup costs, which can be substantial. Under CERCLA, shooting ranges may be liable for government costs incurred during the cleanup of ranges, natural resources damages, and health assessments and/or health effects studies. The following two examples illustrate how shooting ranges (including one operated by the federal government) can be affected by CERCLA.

Southern Lakes Trap and Skeet Club Site, Lake Geneva, Wisconsin, et al.

In 1992, the US Fish and Wildlife Service (USFWS) began an investigation to determine the cause of death of over 200 Canada geese. The geese died as a result of acute lead poisoning after ingesting lead shot, which research indicated came from the Southern Lakes Trap and Skeet Club. The USFWS, in its role as Natural Resource Trustee, took action to recover the cost of damage to the natural resources (i.e., migratory geese) under CERCLA. In addition, EPA pursued a separate action under the Agency's CERCLA response authority. The club had leased the property from the property owners to operate a shooting range. Shortly after EPA sent out the notice of potential liability to the current and former owners and operators of the club site, the club closed permanently.

In 1994, EPA issued an Administrative Order on Consent (AOC) against one current and one former owner of the property where the now closed Southern Lakes Trap and Skeet Club was located. The AOC required the owners to perform a site assessment, which included an evaluation of the costs to restore the wetlands. In 1998, EPA completed activities to clean up the site and restore some of the natural resources and wetlands. In a negotiated settlement, EPA recovered $1 million of the cost of the cleanup.

Walter L. Kamb v. United States Coast Guard, et al.

In another CERCLA action, Mr. Kamb (court appointed property guardian) sued the U.S. Coast Guard, California Highway Patrol, City of Fort Bragg, and the County of Mendocino (the defendants) for recovery of cleanup costs under CERCLA. Mr. Kamb had been appointed by the Mendocino County Superior Court to sell the property on behalf of the property owners. The property was formerly used by defendants as a rifle, pistol and trap range. Soil analysis indicated the presence of lead in the form of leadshot, bullets, pellets, and dust. The court found the defendants were "responsible parties" (liable for cleanup costs) under CERCLA. No apportionment of liability was made and the final determination of each parties' pro rata share of the response cost was deferred.

This case shows that range activity need not affect a water body to trigger CERCLA liability. CERCLA is a powerful statutory authority that can greatly impact current and former range owners/operators. The statute allows for recovery of damages to natural resources, the cost of any health assessment studies and all cleanup costs. Liability may extend to past owners and operators long after a range ceases operation.

1.2.4 Additional Laws and Regulations

Shooting ranges may also be subject to state and local laws and regulations. Many states have adopted their own environmental laws, which are based on federal laws. Specifically, these states have laws and regulations that mirror the CWA and RCRA program laws. EPA-approved state program laws must be as stringent as the federal laws and may be more stringent. Activities at shooting ranges may also be subject to local laws, ordinances and regulations addressing issues such as noise, zoning, traffic, wetlands and nuisance. Often, citizens or neighbors of outdoor shooting ranges can initiate noise nuisance claims against range owners/operators. Because many states have passed legislation protecting ranges from noise nuisance lawsuits, these may turn into claims of environmental violations under the laws discussed above due to the presence of lead and other products at ranges.

1.3 Benefits of Minimizing Lead's Environmental Impact

All ranges will benefit from proactively implementing successful BMPs. Even if range activities currently do not cause adverse public health and environmental impacts, by developing and promoting active lead management programs, ranges will benefit in the following ways:

- **Through a sound lead management program, shooting sports enthusiasts can reduce the potential of lead exposure and contamination to humans, animals and the environment.**
- **A lead management program will result in improved public relations for the range and the shooting sports.** Ranges can promote and publicize their successful BMP programs to improve their public image. Since many of the legal and governmental actions begin with or are due to citizen groups, an active lead management program may improve the public image of the range with these citizen groups.
- **The removal of spent lead from the range presents a clean, well maintained facility, which will increase customer satisfaction.**

- **Lead is a recyclable and finite resource and can be recovered from the active portion of ranges and sold to lead reclaimers.** Frequently, reclaimers do not charge range owners/operators to recover lead from ranges, and owners and operators may receive a percentage of the profit from the sale of reclaimed lead. This factor drives recycling efforts at many ranges.

- **By reducing or eliminating a potential source of lead migration in soil, surface water and groundwater, range owners/ operators may avoid costly and lengthy future remediation activities.**

- **Finally, implementing a BMP program for lead may eliminate or greatly reduce the risk of citizen lawsuits and the legal costs associated with these lawsuits.** Through management and removal practices, lead may no longer represent a threat upon which citizen lawsuits are based.

Range owners/operators may question whether the benefits of a regular and timely BMP program outweigh the efforts of implementing and maintaining a program. The questions may arise especially for ranges at which shooting activities involve waterways, since national attention has focused on ranges located adjacent to water (e.g., *Remington Arms* and the *New York Athletic Club*). However, all outdoor ranges may be subject to legal actions under RCRA and CERCLA authority. All of the benefits for adopting best management practices are available and worthwhile for every range owner and operator.

The following sections provide information that will assist the range owner or operator in implementing a BMP program for recovery and recycling of lead shots and bullets.

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Chapter II: Range Characteristics & Activities to Consider When Implementing Best Management Practices (BMP)

2.0 Background

Since each firing range site is unique, BMPs for lead must be selected to meet site-specific conditions in order to achieve maximum success. A range's physical characteristics and the operational aspects (e.g., volume of shooting, shooting patterns and operating schedules) will effect which BMPs may apply and how they will be implemented. Accordingly, whether designing a new outdoor range or operating an existing range, it is important that BMPs incorporate techniques appropriate for the range's individual characteristics.

Section 2.1 of this chapter identifies the physical characteristics that must be considered when evaluating your range. A summary of common physical characteristics at ranges is also presented in Table 2-1. These factors include:

- Range Size (primarily for shotgun ranges)
- Soil Characteristics
- Topography/Runoff Direction
- Annual Precipitation
- Ground and Surface Water
- Vegetation
- Accessibility

Section 2.2 discusses the operational aspects that must be considered. These factors include:

- Lead Volume
- Size of Shot/Bullets
- Operating Schedule
- Shooting Direction and Pattern
- Range Life Expectancy

In addition, Section 2.3 discusses issues that are specific to implementing BMPs when planning a new range.

2.1 Physical Characteristics

Physical characteristics of ranges, relative to lead management issues, are discussed below.

Range Size

Shotgun range design and type affects the ease of lead shot collection. Larger ranges typically tend to have lead shot that is dispersed over a wider area, while smaller ranges tend to concentrate lead shot in a smaller area. Reducing the area of the shotfall zone will concentrate the shot within a smaller area, allowing for easier cleanup and reclamation. BMP techniques for reducing the shotfall zone at trap and skeet ranges, as well as sporting clay ranges, are discussed in Chapter III.

Soil Characteristics

Spent lead bullets and shot are most often deposited directly on and into soil during shooting. When lead is exposed to air and water, it may oxidize and form one of several compounds. The specific compounds created, and their rate of migration, are greatly influenced by soil characteristics, such as pH and soil types. **Knowing the soil characteristics of an existing range site is a key component to developing an effective lead management plan.**

Soil pH

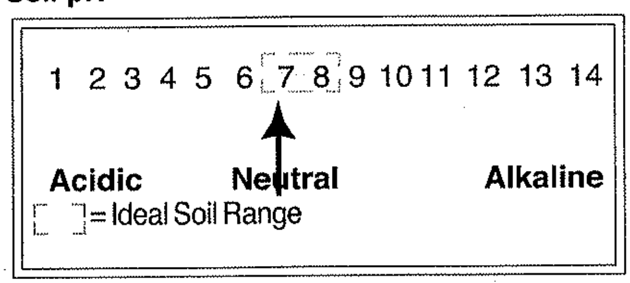

Figure 2-1 – pH scale

Soil acidity is measured as pH on a scale (illustrated as Figure 2-1) between 1 (most acidic) and 14 (most alkaline, or basic), where 7 is termed neutral. Ideal soil pH for shooting ranges is 6.5 to 8.5.[1]

1 National Shooting Sports Foundation, "Environmental Aspects of Construction and Management of Outdoor Shooting Ranges," June 1997.

Lead reacts more readily and may become more mobile under acidic (pH < 6) or higher alkaline (pH>8) conditions. This means that spent lead shot left in or on such soils may eventually break down and contaminate underlying soil. In moderately alkaline soils (pH 7 - 8.5), the lead precipitates out of solution and binds to the soil. This "binding" effect prevents the lead from migrating to the subsurface. In general, soils in the eastern part of the United States tend to be acidic, whereas western soils tend to be more alkaline.

Soil Physical Characteristics

The migration rate of specific lead compounds is affected by the physical characteristics of soil. For example, dense soils, consisting of heavy clays, will prevent the lead compound from moving quickly through the subsurface. Any "free" lead ions become attached to clay particles, with this bond helping to prevent migration. However, with denser soils, the amount of surface runoff increases.

Although clay soils inhibit migration, lead reclamation by contemporary removal machinery tends to be more difficult in clayey conditions. Clayey soils tend to clog the screens and "bind" with shot and bullets. This situation may require additional traditional screening, or perhaps screening using water to enhance separation.

In contrast, sandy soils or gravel may not impede migration because the open pores of these soils allow lead compounds to percolate quickly. Fortunately, lead reclamation activities are more easily conducted in sandy soils. With this in mind, ranges located in sandy soils should remove lead more frequently.

Annual Precipitation

One of the most important factors that influences lead degradation (i.e., chemical reactions) and migration is precipitation. Water, most often in the form of rain, provides the means by which lead is transported. In general, ranges located in areas with high annual/seasonal rainfall[2] have a higher risk of lead migration than those located in arid regions. This is especially true of outdoor ranges using "Steel Bullet Traps."

Steel bullet traps build up a layer of lead residue; these particles are extremely small and more easily transported by rain/water. Also, the smaller the particle, the quicker it will degrade. A bullet trap needs to have a means to collect contact water, or be covered to prevent water from reaching it, and to minimize releases and degradation.

Topography/Runoff Directions

The topography of your range impacts both the ease of lead reclamation and the mobility of the lead. For example, lead reclamation is more successful at ranges where the shotfall zone is relatively flat, since many lead reclamation companies use heavy machinery that cannot operate on slopes or steep hills.

Another important characteristic is the direction in which your range topography slopes. During and after periods of rain, stormwater runoff may wash lead particles or lead compounds off the range. If there are surface water bodies such as lakes, rivers, or wetlands downgradient, the potential for lead to adversely affect the surrounding environment is even greater. Therefore, it is important to identify and control the direction of surface water runoff at your range. BMPs for modifying and controlling runoff are described in detail in Chapter III.

Groundwater

Groundwater depth should be considered when developing a lead management plan since the closer the groundwater is to the surface, the greater the potential for dissolved lead to reach it.

Vegetation

Vegetative ground covers can impact the mobility of lead and lead compounds. Vegetation absorbs rainwater, thereby reducing

2 Heavy annual rainfall is anything in excess of the average annual rainfall, which for the northeast United States (e.g. New York, New Jersey) is between 40 and 45 inches.

Table 2-1 – Common Physical Characteristics at Ranges – Potential Risks and Benefits Associated with Range Operations

Physical Characteristics	Potential Risk to Environment	Potential Benefits in Preventing/Managing Contamination
Clay, acidic soils	Acidic soils contribute to lead dissolution -- increasing the potential for lead contamination -- may increase run-off Difficult to reclaim lead via sifting/raking	May impede percolation of water through contaminated soil Binds "free" lead ions May benefit growth of vegetative covers
Sandy, alkaline soils	Contaminated rainwater can easily percolate through soil and groundwater Extremely alkaline soil will not support vegetation	Alkaline soils may inhibit lead dissolution Easier to reclaim lead via sifting/raking
Sandy, acidic soils	Acidic soils contribute to lead dissolution -- increasing the potential for lead contamination Contaminated rainwater percolates quickly through sandy soils	Easier to reclaim lead via sifting/raking
Steep Rolling Terrain	May promote off-site drainage or drainage to on-site surface water bodies Can impede reclamation of expended shot via raking	None
Flat Terrain	Rainwater may "pond" in areas, promoting lead dissolution and contamination	Expended shot easily recovered Off-site drainage minimized
Wooded areas	May impede lead reclamation activities making equipment difficult to maneuver May provide habitat for wildlife - increasing exposure to lead	None
On-site or contiguous surface water bodies	VERY high potential for contamination when shot fall zone is located over or adjacent to water; increased wildlife exposure; increased lead dissolution. This is NOT an option for successful range location and may be more likely subject to litigation and/or governmental action if lead is deposited into water bodies	None
Vegetation	Lead may be absorbed into grasses, other wildlife food sources	Ground covers slow down surface water run-on and run-off Some vegetation can extract lead ions from the soils

the time that the lead is in contact with water. Vegetation also slows down surface water runoff, preventing the lead from migrating off-site. However, excessively wooded areas (such as those often used for sporting clay ranges) inhibit lead reclamation by making the soils inaccessible to some large, lead-removal machinery. Understanding the type, concentration and variety of vegetation on your range is necessary for developing your lead management program and implementing BMPs at your range.

Accessibility

Accessibility to shotfall zones and backstops is extremely important for lead reclamation activities. A range that is not accessible to reclamation equipment will have difficulty implementing lead reclamation practices.

2.2 Operational Aspects

Operating practices can have a great affect on the volume and dispersion of lead at your range.

Lead Volume

Keeping records of the number of rounds fired over time at your range is important. The number of rounds fired provides a realistic estimate of the quantity of lead available for reclamation. This information helps to determine when reclamation is necessary in order to prevent accumulation of excess amounts of lead, thereby decreasing the potential for the lead to migrate off-site.

Size of Shot/Bullets

Knowledge of the size shot/bullets used on your range may be helpful. Lead reclamation companies generally use physical screening techniques to separate lead shot and bullets from soil. These screens come in a variety of sizes. Knowing what size shot/bullets have been used at your range will allow the reclaimer to maximize the yield of lead shot/bullets at your range.

Shooting Direction and Patterns

Shooting directions and patterns are important to consider when determining the effectiveness of bullet containment devices. For example, many bullet traps are effective in containing bullets fired from specific directions. It is vital that you utilize bullet containment devices that match your range's specific shooting patterns and manufacturers specifications. Understanding the shooting direction and patterns will also help to correctly identify the shotfall zone at trap and skeet ranges.

Shooting into Water Bodies

Shooting into water bodies or wetlands should not occur. Besides the environmental impacts discussed previously, the introduction of lead to surface water bodies will likely cause a range to be susceptible to litigation and/or governmental action. Shooting into water bodies or wetlands is NOT an option for ranges that want to survive in the future.

Range Life Expectancy and Closure

The life span of your range may be impacted by many factors, including financial and environmental issues, noise, and encroachment on residential areas. If your range is slated for closure, contact your local state or EPA representatives for guidance.

2.3 Planning a New Range

As discussed in the previous sections, site characteristics and operational aspects affect lead migration, degradation and reclamation activities at ranges. **If you are planning on opening a new range, you should select and/or design a site in consideration of the factors discussed in this manual.** This will allow you to minimize the potential of lead impacting your site or adjacent properties. A new range owner has the advantage of being able to design a successful lead management program in full consideration of the site characteristics and recommended BMPs. This advanced understanding of operational aspects and requirements will allow you to minimize the potential for lead migration prior to opening.

The most important site selection criteria to consider when selecting a new range location include: topography; surface water flow patterns; and depth to groundwater. If possible, ranges should be developed on flat terrain, as it facilitates reclamation and reduces the chance of off-site migration due to surface water runoff as compared with highly sloped terrain. When considering a prospective location for a range, ask yourself: What is the direction of surface water runoff? Does the site drain to surface water (e.g., streams, rivers) on-site? Off-site? Can the range design be modified to minimize potential runoff? Is reclaimation equipment accessible to the area to clean the range?

By selecting an appropriate location and designing a lead management program in consideration of site characteristics, new shooting ranges can be developed to minimize the potential for lead contamination. Other important site characteristics can be modified. For example, a new shotgun range can be designed to concentrate the shotfall area, vegetation can be added or altered, and the most advantageous shooting direction can be selected. These modifications are BMPs, and are discussed in further detail in Chapter III.

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Chapter III: Best Management Practices (BMPs) For Outdoor Ranges

3.0 Background

To operate an outdoor range that is environmentally protective requires implementing an integrated lead management program, which incorporates a variety of appropriate BMPs. These BMPs create a four step approach to lead management:

- Step 1 - **Control and contain lead bullets and bullet fragments**
- Step 2 - **Prevent migration of lead to the subsurface and surrounding surface water bodies**
- Step 3 - **Remove the lead from the range and recycle**
- Step 4 - **Documenting activities and keeping records**

An effective lead management program requires implementing and evaluating BMPs from each of the four steps identified above and illustrated as Figure 3-1. The BMPs discussed in Sections 3.1 and 3.2 should not be considered alternatives to lead reclamation, but rather practices that should be followed between lead reclamation events.

It is important to note that the cost and complexity of these BMPs vary significantly. **It is your range's individual characteristics that will determine which BMPs should be implemented.** The specific BMPs are described more fully below.

3.1 Bullet and Shot Containment Techniques (Step 1)

3.1.1 Bullet Containment

Knowing where spent lead is allows the appropriate BMP to be used. The single most effective BMP for managing lead in these areas is by bullet containment. Owners/operators should employ a containment system that allows for the maximum containment of lead on-site. The containment systems mentioned in this section are for reference only. Each containment design for a range is site specific. Each owner/operator must look at the various factors in determining which containment system is best for his or her range. Some factors include: overhead, cost of installation, maintenance (e.g., creation of lead dust from steel containment systems). Range owner/operators should consult with various contractors to determine which containment system is best for their range.

Step 1	Step 2	Step 3	Step 4
Control and Contain (Section 3.1)	Prevent Migration (Section 3.2)	Remove and Recycle (Section 3.3)	Document Activities and Record Keeping (Section 3.4)
-- Bullet containment ~ Earthen Backstops ~ Sand Traps ~ Steel Traps ~ Lamella or Rubber Granule Traps ~ Shock Absorbing Concrete -- Shot Containment ~ Reduce shotfall zones	-- Monitor and adjust soil pH (e.g., lime spreading) -- Immobilize lead e.g., phosphate spreading) -- Control runoff ~ Plant vegetation and utilize organic ground cover ~ Implement engineered runoff controls	-- Hand raking and sifting -- Screening -- Vacuuming -- Soil washing -- Working with a reclaimer -- Recycling	-- Document number of rounds fired/shot size -- Document BMP(s) used at ranges to control migration -- Document date and provider of services -- Keep records for the life of the range and at east 10 years after closing -- Evaluate the effectiveness of BMPs used

Figure 3-1 – 4 Steps to Build a Successful Lead Management Program Utilizing a Variety of BMPs

This section discusses BMPs for controlling spent lead bullets and fragments in a "controlled" and well-defined area behind the target area. Containing bullets and bullet fragments is critical to successfully managing lead.

There are a variety of containment device options available that serve as BMPs to control lead. The principle behind all of them is trapping and containing the actual bullet. They include:

- Earthen Berms and Backstops
- Sand Traps
- Steel Traps
- Lamella or Rubber Granule Traps
- Shock Absorbing Concrete

For each type of trap, design variations have been developed to fit the specific needs of an individual range. Below are discussions of each general category of trap. Some bullet containment devices are so comprehensive that they virtually eliminate lead's contact with the environment.

However, it is important to discuss all types of bullet containment devices because they are part of comprehensive BMPs for managing lead at rifle and pistol ranges.

EPA does not endorse any bullet containment design as being "better" than another. Different containment designs attempt to eliminate lead's contact with the environment, however, additional BMPs may be required for lead management.

EPA recommends that you discuss your range's bullet containment needs with a variety of vendors before deciding what type of containment device to use. This manual does identify the possible advantages and disadvantages associated with each containment device in Table 3-1, at the back of this chapter.

Earthen Berms and Backstops

Perhaps the most common bullet containment system at rifle and pistol ranges is the earthen backstop (earthen material, i.e., sand, soil, etc., which is located directly behind the targets). The earthen backstop is generally between 15 and 20 feet high with a recommended slope as steep as possible[1]. In many instances, backstops may be naturally occurring hillsides. When using an earthen berm or backstop, ensure that the uppermost layer (to a depth of one to two feet) exposed to the shooting activity is free of large rocks and other debris. These materials tend to increase ricochet and bullet fragmentation, which will, in turn, make lead reclamation activities more difficult, not to mention possible safety issues.

Removal of lead from earthen backstops may require lengthy reclamation (see Section 3.3) of the soil to remove the lead. Continued use of the backstop without removing the lead may result in increased ricochet of bullets and fragments. In addition, the backstop may lose its slope integrity because of "impact pockets" that develop. Once the lead has been removed from the earthen backstop, the soil can be placed back on the range and used again. Adding lime and phosphate during the rebuilding process is recommended as appropriate (see Section 3.2). However, other bullet containment techniques, including those listed below, should be considered prior to reestablishing an earthen backstop.

Sand Traps

A variation of the earthen backstop is the sand trap. Sand traps range from those that are simply mounds of sand or soil located directly behind the bullet targets, which serve as backstops to a sand trap that employs a system designed to contain, collect and control lead and contact water. This sand trap uses a grade of sand that is ballistically acceptable. Regular maintenance must be performed to remove larger particles (bullets) from the impact area. These traps are placed so that bullets fired across the range pass through the targets and become embedded in the sand. These traps are typically 15 to 20 feet high with a slope as

1. National Rifle Association, "The NRA Range Source Book: A Guide to Planning and Construction," June 1998

steep as possible. The most important design criterion for these traps is that the uppermost layer (to a depth of 1 to 2 feet) be free of large rocks and other debris to reduce ricochet and bullet fragmentation, and to facilitate reclamation efforts. There may also be an impermeable layer (e.g., clay or liner) under the sand to prevent lead from contacting the soil underlaying the trap.

Sand traps come in various designs and levels of complexity. The sand trap may be ballistic grade sand contained in a high backstop, or a more complex "Pit and Plate" system. The Pit and Plate system uses an angled, steel deflection plate cover that helps to direct bullets and bullet fragments to the top layer of sand only. Some of the more sophisticated sand traps incorporate lead recovery devices. However, the Pit and Plate may increase the surface-to-mass ratio of the bullet splatter and, therefore, may increase environmental risk of lead migration.

Regardless of the type of sand trap that is used, the traps become saturated with bullets/bullet fragments. Once this happens, the sand must be sifted (see Section 3.3) to remove the bullets. The recovered bullets can then be sold to a lead recycler (this is discussed in more detail later in the chapter). After sifting, the sand can be returned to the trap. Continued use of the trap, without removing the lead, may result in an increased risk of ricocheting off the backstop and thus creating an increased safety hazard. Furthermore, the sand trap will become unstable over time. Sand traps may be located over an impermeable liner, to prevent lead from contacting soil underlying the trap. This will provide additional protection to soil and groundwater.

Steel Traps

Steel traps are located directly behind the targets so that expended bullets, along with bullet particles, are directed into some form of deceleration chamber. Once inside the chamber, the bullets decelerate until the bullets/bullet particles fall into collection trays at the bottom of the deceleration chamber. When the trap is full, or on a more frequent basis, the spent lead can easily be reclaimed for recycling.

With some steel traps, expended lead bullets may not come in direct contact with soils, thereby possibly minimizing lead's contact with the environment. Consequently, the need for other BMPs (e.g., lime spreading, and/or engineering controls), such as those required at ranges with unlined earthen backstops or unlined sand traps, may be avoided if this trap design is selected for the range's bullet containment device. In addition, bullet removal is somewhat easier than from a sand trap, and may only require emptying the bucket or tray containing the bullets and/or bullet fragments. However, an increase of lead dust and fragmented lead may be an additional environmental concern. Therefore, understanding the amount of lead dust and fragments is important to a successful lead management program. Also, some steel trap designs are not intended for shooting at different angles, therefore limiting the shooter to shooting straight on (no action shooting).

As with sand traps, steel traps vary in design and complexity. For example, the Escalator Trap has an upward sloping deflection plate that directs bullets into a spiral containment area at the top. The Vertical Swirl Trap is a modular, free standing trap with four steel plates that funnel the bullets into a vertical aperture in which they spin, decelerate, and become trapped in a bullet collection container. The Wet Passive Bullet Trap is equipped with steel deflection plates that slope both upward and downward. The upwardly sloped deflection plate is covered with an oil/water mixture to help reduce the occurrence of ricochet and bullet fragmentation. The bullet follows its own path in the round deceleration chamber for bullet recycling.

Lamella and Rubber Granule Traps

The Lamella Trap uses tightly-hanging, vertical strips of rubber with a steel backing to stop bullets. This trap is located directly behind the targets and, in many cases, the targets may actually be mounted to the trap. Lead removal requires mining the bullets from the rubber. The Rubber Granule Trap uses shredded rubber granules, housed between a solid rubber front and a steel backing, to stop bullets once they pass through the target. For both traps, the bullets remain intact, thus eliminating lead dust and preventing lead and jacket back splatter. Depending on the design of the rubber trap, the bullet either remains embedded in the rubber strip or falls to the bottom of the trap, from which the bullets are removed for recycling.

These traps, when properly installed, are intended to increase safety by decreasing the occurrence of back splatter and eliminating the introduction of the lead dust into the air and ground. However, there are several concerns over their use, since they may:

- require additional maintenance;
- in some cases, present a fire threat under extremely high volume use (due to heat from friction created upon bullet impact);
- not withstand weather elements over the long term; and
- cause the rubber particles to melt to the lead bullets, making reclamation more difficult.

With the availability of fire-resistant rubber and gels (see Appendix A), these issues are becoming less of a concern than in earlier models.

Shock Absorbing Concrete

In addition to the bullet containment devices discussed above, there are new designs and innovations continually being developed. One of these innovative bullet containment devices is Shock Absorbing Concrete (SACON). SACON, which has been used as a bullet containment device since the 1980s and was extensively field tested by the military, has become commercially available in the past several years as a backstop material for small arms ranges. For conventional rifle and pistol ranges, SACON may provide a means to easily reclaim lead. Additionally, crushed, lead-free SACON can be recycled (recasted) after bullet fragments have been removed by adding it to other concrete mixtures for use as sidewalks, curbs, etc.

3.1.2 Shot Containment

Reducing the Shotfall Zone

Unlike rifle and pistol ranges, the area impacted by lead shot fired at trap, skeet and sporting clays ranges is spread out and remains primarily on the surface. **Knowing where spent lead is allows the appropriate BMP to be used. The single most effective BMP for managing lead in these areas is reducing shotfall zones.**

Concentrating the lead shot in a smaller area by modifying the shooting direction facilitates lead management by providing a smaller and more dense area of lead to both manage in-place and reclaim, thereby making the management and reclamation process simpler and more effective.

Sporting Clays Courses

Technologies have been developed to assist in reducing the range size of trap and skeet, and sporting clays facilities. The National Sporting Clays Association (NSCA) supports and promotes the Five-Stand Sporting Clays compact course design for shooting sporting clay targets, invented by Raymond Forman of Clay-Sport International, Cochrane, Alberta, Canada. The targets are directed over a smaller area than in English Style Sporting Clays (conventional sporting clays). It was originally designed to be overlaid on a conventional trap or skeet field and to be an alternative to earlier designs, which cover a much larger area. Another design, known as the National Rifle Association (NRA) Clays, is a portable target throwing unit which concentrates 15 rail-mounted machines on a two-story flatbed trailer. The NRA has also developed "compact sporting," which is specifically for sporting clay facilities. This practice alters the angle that the target is thrown to concentrate the shotfall zone.

Skeet Fields

The typical single skeet field has a shotfall zone that is fan-shaped. For skeet fields with multiple stands side-by-side, the shotfall zones would overlap creating a shotfall zone that has a concentration of shot near the center of the fan.

Trap Fields

One way to reduce the shotfall zone at trap fields is to build the fields at an angle to one another. This will make the shape of the shooting dispersal pattern smaller and more concentrated. However, if you do decide to choose this option, be aware of safety issues when designing the overlapping shotfall zones.

For a range with only one trap field, one way to minimize the shotfall zone is to keep trap machines set in as few holes as possible (e.g., the number two or three hole setting). This reduces the area of lead concentration by limiting the angles for pigeon throwing, and therefore the area for lead shot fall. However, when two or more trap fields are positioned side by side, the shotfall zone will be continuous regardless of the "hole" setting.

Shot Curtains

Another method to consider for concentrating lead shot is the use of a shot curtain. This device is emerging as a potentially effective tool to keep lead shot out of selected areas of the range and, thereby, reduce the size of the shotfall zone and corresponding cost of reclamation. Different designs and material have been utilized in shot curtains and a number are in operation. The effectiveness of shot curtains is site specific and their long term viability and expense have yet to be fully determined.

3.2 BMPs to Prevent Lead Migration (Step 2)

This section discusses BMPs for preventing lead migration. These BMPs include:

- **Monitoring and adjusting soil pH**
- **Immobilizing lead**
- **Controlling runoff**

These BMPs are important for all outdoor ranges.

3.2.1 Monitoring and Adjusting Soil pH and Binding Lead

Lime Addition

The BMP for monitoring and adjusting soil pH is an important range program that can effect lead migration. Of particular concern are soils with low pH values (i.e., acidic conditions), because lead mobility increases in acidic conditions since the acid of the soils contributes to the lead break down. **The ideal soil pH value for shooting ranges is between 6.5 and 8.5**. This BMP is important because many soils in the eastern United States have pH values lower than 6.[2]

To determine the pH of your soil, purchase a pH meter at a lawn and garden center. The pH meters are relatively inexpensive but valuable tools in the management of lead at your range. If the soil pH is determined to be below 6, the pH should be raised by spreading lime. **It is recommended that the pH be checked annually.**

One way to control lead migration is by spreading lime around the earthen backstops, sand traps, trap and skeet shotfall zones, sporting clays courses and any other areas where the bullets/shots or lead fragments/dust accumulate. For example, lead mobilized in rainwater from the lead that spatters in front of backstops after bullet impacts can be effectively controlled by extending a limestone sand layer out about 15 feet in front of the backstop. Likewise, spreading lime over the shotfall zone will help to raise the pH of the very top soil layer to a pH closer to ideal levels and reduce the migration potential of lead. This is an easy, low cost method. Spreading lime neutralizes the acidic soils, thus minimizing the potential for the lead to degrade. Lime can be easily spread by using a lawn fertilizer drop spreader available at any lawn and garden center.

Smaller forms of limestone (powdered, pelletized, and granular) are better suited

2 National Shooting Sports Foundation, "Environmental Aspects of Construction and Management of Outdoor Shooting Ranges," June 1997

because they dissolve and enter the soil more quickly then larger forms. However, the smaller forms of lime must be replenished more often. Conversely, limestone rock dissolves more slowly but does not need to be replenished as often. The larger rock form is better suited for drainage ditches, where it can decrease lead mobility by raising the pH of the storm water runoff.

Another way to control lead migration in earthen backstops is to break the capillarity within the base of the backstop. Most porosity in the soil material used in backstop is of capillary size, and, as a result, water is pulled upward into a capillary fringe within the base of the backstop. The height to which the water will rise in an earthen backstop depends on the soil material in the backstop. Water will rise more then 6 feet in clay, 3.3 feet in silt, 1.3 feet in fine sand, 5 inches in coarse sand, and only 2 inches in gravel.

Because of capillarity, the spent bullets may be in contact with acidic rainwater for a longer period of time, hence more lead is dissolved. Breaking the capillarity by adding a layer of limestone or gravel to the base of the backstop should reduce the rate of deterioration of spent bullets, the erosion of the backstop, and the amount of lead going into solution in the water in the backstop. Also, any lead dissolved should precipitate out of solution as the acids are neutralized and the pH raised from the water passing through and reacting with the limestone.

Lime spreading is an especially important method for implementing this BMP at sporting clays ranges where heavily wooded areas are less accessible to conventional lead removal equipment. These types of ranges also tend to have more detritus (e.g., leaves, twigs, etc.) on the ground, which can increase soil acidity as they decompose. **In these areas, semiannual monitoring of the soil pH levels is suggested.**

Spreading bags of 50 pounds (at ranges with sandy soils) or 100 pounds (at ranges with clayey soils) per 1,000 square feet of range will raise the pH approximately one pH unit for a period of between one and four years, respectively. The market price of lime in either the granular or pelletized form commonly ranges from approximately $2.00 to $4.00 per fifty pound bag.

Table 3-2 provides information for raising pH levels of clay soils in temperate climates (i.e., Mid-Atlantic/Northeast). Additional information on the amount of lime to apply may also be found on the bags of the purchased lime and/or from the local lawn and garden center. It should be noted that if the soil pH is below 4.5, the addition of lime may only raise the soil pH to approximately 5. In this situation, other BMPs should be used as well. If the soil pH is above the ideal range upper value (8.5), do not add lime. Adding lime to a soil of this pH could result in mobilization of the lead. Lime spreading may be done at anytime during the year, except when the ground is frozen.

Additionally, it is important to remember to monitor the soil pH annually, as the effectiveness of the lime decreases over time. Additional routine applications will be necessary throughout the life span of most ranges.

Table 3-2 – Calculating Weight of Lime to Increase Soil pH Values*

		Current pH							
		4.0	4.3	4.5	4.8	5.0	5.5	6.0	6.5
Desired pH	5.0-6.0	14	11	8	5	3	-	-	-
	6.5-8.5	-	-	-	20	17	11	7	-

* Lime requirements stated as pounds of lime/100 square foot of problem area for clay soils in temperate climates (i.e., Mid-Atlantic/Northeast US).

Phosphate Addition

In addition to lime spreading, another way to control lead migration is phosphate spreading. This method is recommended where lead is widely dispersed in range soils, a range is closing, or there is a high potential for vertical lead transport to groundwater (e.g., low soil pH, shallow water table). Under these circumstances, range soils may benefit from phosphate treatment. Unlike lime spreading, the main purpose of phosphate spreading is not to adjust soil pH but to bind the lead particles. This process also decreases the potential amount of lead that can migrate off-site or into the subsurface. Phosphate spreading can be done either separately or in conjunction with lime spreading. Generally, 15 to 20 pounds of phosphate per 1,000 square feet will effectively control the lead.

Phosphate spreading is especially recommended for sporting clays ranges and those parts of ranges not easily accessible by reclamation equipment. Phosphate spreading should be repeated frequently during the range's lifetime. See pilot testing under "Other Ways to Bind Lead" below for proper frequency for replacing phosphate.

You can purchase phosphate either in its pure form, as phosphate rock, or as lawn fertilizer. The average lawn fertilizer costs approximately $7.00 per 40 pound bag. If you purchase lawn fertilizer, remember to check the bag for the actual percentage of phosphate. Most fertilizers contain 25% phosphate, so that if you purchase a 40 pound bag of fertilizer that contains 25% phosphate (i.e., 10 pounds of phosphate) you will need to spread 80 pounds of fertilizer per 1,000 square feet of the backstop. A typical fertilizer drop spreader can be used for distributing the phosphate. Like lime, phosphate should not be spread when the ground is frozen. In addition, it is not advised to use phosphate near water bodies since it contributes to algal blooms. Rock phosphate is a better choice if water is nearby.

Other Ways to Bind Lead

Although it may be possible to minimize lead's mobility by spreading fertilizers that contain phosphate at impacted areas of the range, a more comprehensive procedure for immobilizing leachable lead in soils, by using pure phosphate in rock form or a ground phosphate rock [Triple Super Phosphate (TSP)], was developed and patented by the U.S. EPA/Ohio State University Research Foundation and RHEOX, Inc. This procedure used a three step approach to minimize lead's mobility. The first step was to identify the boundaries of the area of the range to be treated. This included not only determining the length and width of the range area, but also the depth of lead within the area.

Depth was determined by taking sample cores of the area, which also identified "hot spots" where lead accumulation was greatest. Once the area was identified, the second step was to treat the area with TSP. Pure phosphate rock was used rather then fertilizers, as this phosphate is insoluble in water and will not cause an increase in phosphate runoff.

In this step, pilot testing was conducted. Here, various amounts (in increasing percentages by weight) of TSP were added to the affected soil areas, then the area was tested according to an EPA test method that identified the amount of leachable lead in a given soil sample. This test is called the Toxicity Characteristic Leaching Procedure, or TCLP. Separate TCLP testing of the range's hot spots was conducted.

Upon completion of the pilot testing, which determined the amount of TSP needed at the range, the third step was to begin actual treatment of the range. Where the depth of the lead accumulation was shallow (less than two feet), then standard yard equipment, such as tillers, seed/fertilizer spreaders, and plows were used to mix TSP with the affected soil. Where the affected area's lead accumulation was deeper than two feet, an auger was required to mix the TSP with the affected soil. Random testing of the range ensured the effectiveness of the treatment level.

3.2.2 Controlling Runoff

The BMPs for controlling soil erosion and surface water runoff are important to preventing lead from migrating off-site. There are two factors that influence the amount of lead transported off-site by surface water runoff: the amount of lead fragments left on the range and the velocity of the runoff.

The velocity of the water can successfully be controlled at outdoor ranges by: (1) using vegetative, organic, removable and/or permanent ground covers; and (2) implementing engineered controls which slow down surface water runoff and prevent or minimize the chances of lead migrating off-site. Bear in mind that safety considerations and potential ricochets need to be considered when implementing any engineered controls.

<u>Vegetative Ground Cover</u>

Planting vegetative ground cover (such as grass) is an important and easy erosion control method. Vegetation provides several benefits by minimizing the amount of lead that will run off the land surface during heavy rainfall. It is important to use a mixture of grass seeds to ensure that the cover will last into the future (i.e., annual rye grass lasts one year and dies and perennial rye grass lasts three to four years, then dies off). Fescue grasses form useful mats that are effective in controlling erosion.

Ground cover absorbs rainwater, which reduces the amount of water the lead is in contact with, as well as the time that the lead is in contact with the water. Furthermore, the ground cover will divert and slow down surface water runoff, thus helping to prevent lead from migrating off-site.

Grasses yield the greatest benefit at rifle and pistol ranges where the bullet impact areas are sloped, and water runoff and soil erosion may be more likely. Specific recommendations are to:

- Utilize quick growing turf grass (such as fescue and rye grass) for the grass covering of backstops, which can be removed prior to reclamation and replanted thereafter;
- Avoid vegetation that attracts birds and other wildlife to prevent potential ingestion of lead by wildlife; and
- Use grass to direct surface water drainage away from the target area (e.g., planting them at the top of the backstop or sand trap). This will minimize the water's contact with lead bullet fragments, minimizing the potential for lead migration.

Grass is not impermeable; however, it does slow down the rate of flow and reduce the amount of lead entering the soil via rainwater. Remember, grass requires periodic maintenance (i.e., mowing) to maintain its effectiveness as well as for aesthetic reasons.

<u>Mulches and Compost</u>

Mulches and composts can reduce the amount of water that comes in contact with the lead fragments. In addition, mulches and compost contain hermic acid, which is a natural lead chelating agent that actually sorbs lead out of solution and reduces its mobility. At a minimum, the material should be two inches thick. These materials can be spread over any impacted area and/or low lying areas where runoff and lead may accumulate. Like vegetative covers, organic surface covers are not impermeable. In addition, the organic material needs periodic replacement to maintain effectiveness and aesthetic integrity. Furthermore, these materials should be removed prior to any lead removal event, as they may impede sifting or screening. **Note that these materials tend to be acidic (especially during decomposition), so, if low pH is a concern at your range, this option may not be appropriate. Again, however, lime may be used to control pH (see Section 3.1.1)**

<u>Surface Covers</u>

<u>Removable Surface Covers</u>

Removable surface covers may be effective at outdoor trap and skeet ranges. In this case, impermeable materials (e.g., plastic liners) are placed over the shotfall zone during non-use periods. This provides the range with two benefits during periods of rainfall: (1) the shotfall zone is protected from erosion; and (2) the spent lead shot is contained in the shotfall zone and does not come in contact with rainwater.

Permanent Surface Covers

For outdoor rifle and pistol ranges, impact backstops and target areas can also be covered with roofed covers or other permanent covers to prevent rainwater from contacting berms. However, this method may be less desirable because of the cost to install the roof, which must be carefully designed to avoid safety issues with ricochets, etc.

For shotgun and other ranges, synthetic liners (e.g., asphalt, Astroturf™, rubber, other synthetic liners) can also be used beneath the shotfall zone to effectively prevent rainwater or runoff from filtering through lead and lead contaminated soil. Synthetic liners will generate increased runoff, which must be managed, however. No single type of liner is suitable for all situations based on site characteristics. Therefore, liners must be chosen on a site-specific basis, bearing in mind the site's unique characteristics, such as soil type, pH level, rainfall intensity, organic content of soil, and surface water drainage patterns.

Engineered Runoff Controls

Runoff control may be of greatest concern when a range is located in an area of heavy annual rainfall because of an increased risk of lead migration due to heavy rainfall events. A "hard" engineered runoff control may be needed in this situation. A heavy rainfall event is defined as rainfall that occurs at such a rate that it cannot be absorbed into the ground and causes an increase in the volume and velocity of surface runoff. The impacts of rainfall are greater in rolling or sloped terrain (increases velocity of runoff) or where surface water bodies are located on, or immediately adjacent to, the range.

Examples of "hard" controls include:

- Filter beds
- Containment Traps and Detention Ponds
- Dams and Dikes
- Ground Contouring.

Designing and implementing these "hard" engineering controls may require the assistance of a licensed professional civil engineer. They are included in this manual to offer the reader a general understanding of these BMP options. However, this manual does not offer specific instructions for construction and operation of these controls. For information about designing and implementing any of these controls, or assistance with other range design questions, contact a licensed professional civil engineer having applicable experience or the NRA Range Department, at (800) 672-3888, ext. 1417. The National Sports Shooting Foundation (NSSF) may be contacted at (203) 426-1320 for specific references regarding the use and design of these controls.

Filter Beds

Filter beds are engineering controls built into an outdoor range to collect and filter surface water runoff from the target range. The collected runoff water is routed to a filtering system, which screens out larger lead particles, raises the pH of the water (thus reducing the potential for further lead dissolution), and drains the water from the range area. This technique may not completely prevent lead from entering the subsurface, since lead bullets, fragments and large particles may still remain on the range.

Filter beds should be established at the base of the backstop (see Figure 3-2). In addition to mitigating off-site migration, the filter beds work to raise the pH of the rainwater, which has fallen on the target range, to reduce lead dissolution, and to strain small lead particles out of the rainwater. The filters typically consist of two layers: a fine-grained sand bed underlain by limestone gravel or other neutralization material. By design, the backstops and berms direct the runoff so that it drains from the range to the filters. The collected water then soaks through the top sand layer into the neutralization material,

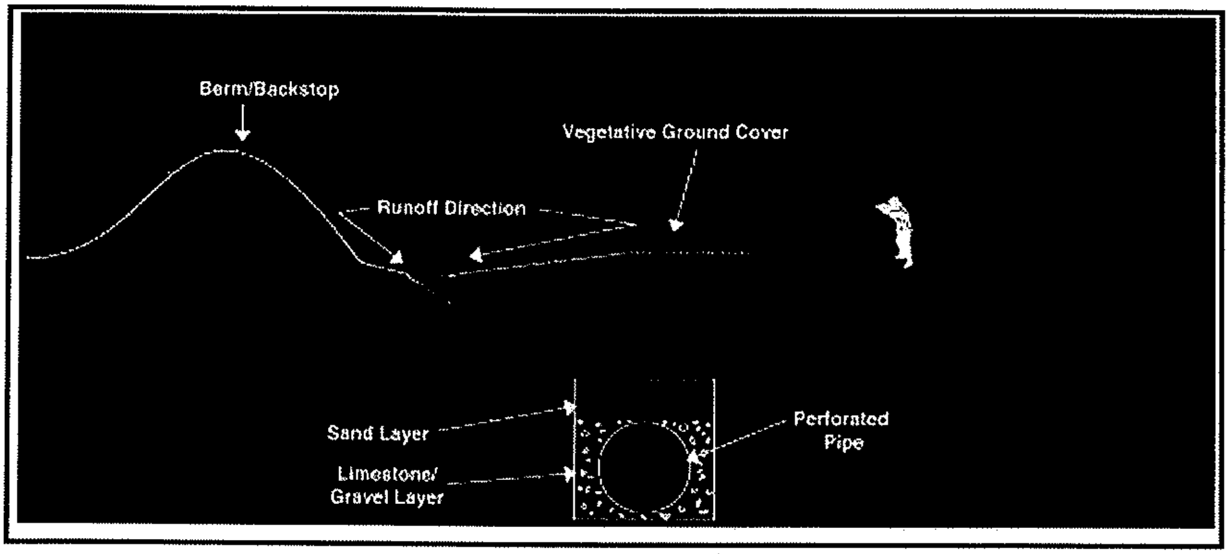


Figure 3-2 – Sample Filter Bed System (Adapted from Proceedings for National Shooting, Range Symposium, October 17-19, 1993, North American Hunting Club and Wildlife Forever)

which raises the pH of the filtrate. The lead particles in the rainwater are collected on the sand, while the pH-adjusted water drains through the filter to a perforated drainage pipe located within the limestone gravel.

Filter beds are designed to capture fine particles of lead transported in surface water runoff. They are not designed to capture bullets. The operation and maintenance requirements of filter beds are minimal. Maintenance activity is limited to periodic removal of debris (such as litter, leaves, etc.) and occasional replenishment of the limestone.

The use of filter beds is most effective on sites with open, rolling terrain where surface water runoff is directed to them. At existing rifle and pistol ranges, a limited system of trenches and filters can be installed at the base of natural soil backstops or at natural drainage depressions.

Containment Traps and Detention Ponds

Containment traps and detention ponds are designed to settle out lead particles during heavy rainfall. Typically, they are depressions or holes in the range's drainage paths. Here, the lead-containing runoff passes through the trap or pond, allowing the lead bullet fragments to settle out. Vegetative cover can be placed in the drainage path to increase the effectiveness of containment traps and ponds by further reducing the velocity of runoff and allowing for more lead fragments to settle from the runoff. It is important to regularly collect the lead and send this lead to a recycler.

Dams and Dikes

At shotgun ranges, dams and dikes can also be used to reduce the velocity of surface water runoff. Dams and dikes must be positioned perpendicular to the direction of runoff to slow the flow of surface water runoff. To accomplish this, determine the direction of the range's surface water runoff. This will be particularly obvious at ranges with sloped terrain. The dams or dikes should be constructed using mounds of dirt that are approximately a foot high. These mounds should transect the entire range perpendicular to the stormwater runoff direction.

These runoff controls are most important at ranges at which off-site runoff is a potential problem, such as ranges where the lead accumulation areas are located upgradient of a surface water body or an adjacent property. Since lead particles are heavier than most other suspended particles, slowing the velocity of surface water runoff can reduce the amount of lead transported in runoff.

Ground Contouring

Another mechanism to slow runoff and prevent lead from being transported off site is ground contouring. By altering drainage patterns, the velocity of the runoff can be reduced. Furthermore, in areas where pH is high (resulting in a lower potential for lead dissolution), the soil can be graded or aerated to increase the infiltration rate of precipitation, so that rainwater is more easily absorbed into the soil. This slows down or prevents surface water runoff and off-site migration. It should be pointed out that this design, in effect, collects lead in the surface soils. Therefore, range operation and maintenance plans should include lead reclamation as well as adjusting the pH, and adding phosphate.

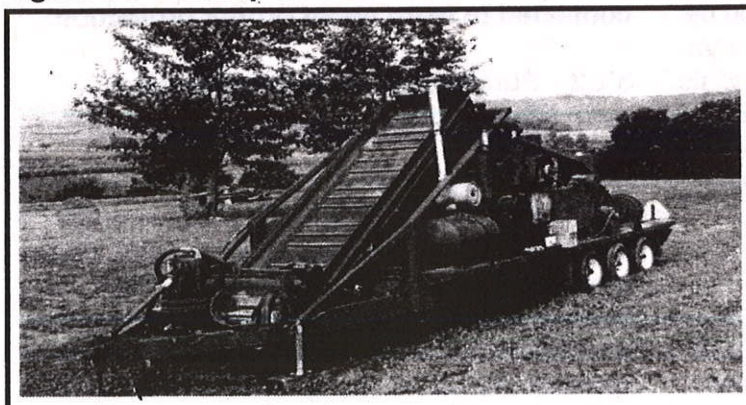
3.3 Lead Removal and Recycling (Step 3)

To successfully minimize lead migration, the most important BMP for lead management is lead reclamation. Implementing a regular reclamation program will allow you to avoid expensive remediation and potential litigation costs. Ranges in regions with high precipitation and/or with acidic soil conditions may require more frequent lead recovery since the potential for lead migration is greater. In regions with little precipitation and/or where the soil is somewhat alkaline, spent bullets may be allowed to accumulate on the soil for a longer time between reclamation events. It should be noted that to ensure that lead is not considered "discarded" or "abandoned" on your range within the meaning of the RCRA statute (i.e., a hazardous waste), periodic lead removal activities should be planned for and conducted. This typically requires one or more of the following:

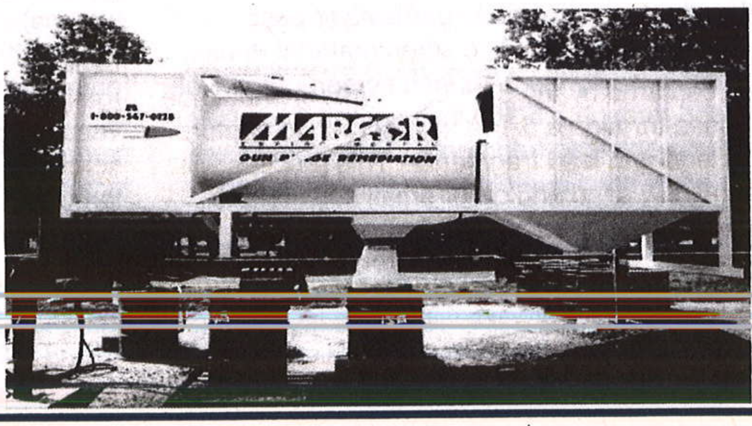
- Hand Raking and Sifting
- Screening
- Vacuuming
- Soil Washing (Wet Screening, Gravity Separation, Pneumatic Separation)

These methods are discussed in detail below. Figure 3-3 provides examples of common lead reclamation equipment.

Figure 3-3 – Examples of Common Lead Reclamation Equipment



Example of shaker system.
Courtesy of National Range Recovery



Example of final separation device ***(Patented Pneumatic Separation Unit) used with a Shaker System. Courtesy of MARCOR.***

Also, it is important to be aware that state regulations may require that the material being sent for recycling have a minimum lead content in order to qualify as a scrap metal that can be shipped under a bill of lading (i.e., exempt from RCRA).

3.3.1 Hand Raking and Sifting

A simple BMP that can be done by club members, particularly at small ranges, is raking and/or sifting bullet fragments from the soil. Sifting and raking activities should be concentrated at the surface layer. This is a low-technology and low-cost management alternative for lead reclamation. Once collected, the lead must be taken to a recycler or reused. Arrangement with a recycler should be made prior to collecting any spent lead to avoid having to store the lead and avoid potential health, safety and regulatory concerns associated with storing lead.

At trap and skeet ranges, conducting sifting and raking activities in the shot fall zone (approximately 125 - 150 yards from the shooting stations) will yield the most lead. For sporting clay ranges, these activities should be conducted around tree bases, where lead shot tends to collect. Basically, the process consists of raking with a yard rake the topsoil in the shot fall areas into piles, as if you were raking leaves, removing any large debris (e.g., rocks, twigs, leaves, etc.), and then sifting the soil using screens.

Once the soil has been raked and collected, pass it through a standard 3/16 inch screen to remove the large particles. This process will allow the lead shot sized particles to pass through the screen. The sifted material (those not captured by the 3/16 inch screen) should be passed through a 5/100 inch screen to capture the lead and lead fragments. This process will also allow sand and other small sediment to pass through the screen. Screens can be purchased at many local hardware stores. The screens should be mounted on a frame for support. The frame size will vary based on the technique used by each range. For example, if one person is holding the framed screen, it may be better to use a smaller frame (2 feet by 2 feet) whereas, if several people are holding the framed screen, it can be larger.

Raking and sifting can be performed by club members on a volunteer basis. Some clubs provide incentives, such as reduced fees, to members who assist with the lead removal process. Other clubs have hired college students during the summer. A number of small clubs have found that reloaders will volunteer to rake in exchange for collected shot.
Hand sifting and raking are cost effective lead removal techniques for small ranges, or low shooting volume ranges. However, these techniques may not be appropriate for situations in which there is a large volume of lead on the range. In this instance, reclamation machinery may be more appropriate.

Note: Those conducting the hand raking and sifting reclamation at ranges should protect themselves from exposure to lead. Proper protective gear and breathing apparatus should be worn. The Occupational Safety and Health Administration (OSHA) or an appropriate health professional should be contacted to learn about proper protection.

3.3.2 Purchasing/Renting Mechanical Separation Machinery

Reclamation equipment may be rented from local equipment rental services. One type of machine that it may be possible to rent for lead shot reclamation is known as a screening machine (also referred to as a mobile shaker, gravel sizer, or potato sizer). This device uses a series of stacked vibrating screens (usually two screens) of different mesh sizes and allows the user to sift the lead shot-containing soil [gathered by hand raking, sweeping, or vacuuming (discussed above)]. The uppermost screen (approximately 3/16 inch mesh) collects larger than lead shot particles, and allows the smaller particles to pass through to the second screen. The second screen (approximately 5/100 inch mesh) captures lead shot, while allowing smaller particles to pass through to the ground. The lead shot is then conveyed to a